

EFFECTS OF DIETARY FAT, SEASON AND BREED TYPE
ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS
OF BEEF STEERS

By

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This manuscript is dedicated
to the memory of my father,
Jose Marcondes Cesar (Juquita).

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Forty-seven crossbred steers were used to study the effect of diet (control versus fat added), breed type (Brahman-European crossbreds versus European crossbreds) and period of the year (cool versus warm) on feedlot performance and carcass characteristics. The overall means for average daily gain and feed efficiency were 1.59 kg and 5.18 kg DM/kg gain, respectively. Addition of fat to the diet did not improve ($P > .60$) feedlot performance, but increased ($P < .0001$) digestible ether extract of the diet from 3.25% for the control to 6.59% for the fat added diet. Breed type did not affect ($P < .44$) any of the feedlot traits studied. Average daily gain was higher ($P .07$) for steers fed during the warm period (1.65 kg) than for those fed during the cool period (1.52 kg). Average daily dry matter and gross energy intakes were higher ($P < .0001$) for steers fed during the warm period. Steers fed the control diet had a better ($P < .10$) yield grade (2.7) than those fed the fat added diet (2.9). Fat added to the diet

negatively affected marbling score ($P < .0011$). Loin steaks from steers fed the fat added diet were more juicy ($P < .03$). No differences ($P > .40$) were found between steers of the two breed types for USDA quality grade or carcass maturity. Loin steaks from European crossbred steers were more juicy and tender ($P < .10$) and had a lower ($P < .10$) shear value. Steers fed during the cool period had a better ($P < .05$) yield grade (2.7) than those fed during the warm period (3.0) and a larger ($P < .03$) ribeye area per 100 kg hot carcass.

Addition of fat to the diet did not affect ($P > .15$) total energy in the soft tissues of the carcass, estimated total energy deposited in the soft tissues of the carcass during the feedlot phase, or efficiency of gross energy utilization. Brahman-European crossbreds had a higher ($P < .06$) amount of estimated total energy deposited in the fat and lean tissues of the carcass during the feedlot phase than the European-crossbreds. Breed type did not affect ($P > .21$) efficiency of gross energy utilization.

Steers fed during the cool period did not differ ($P > .74$) from those fed during the warm period for estimated total energy deposited in the soft tissues of the carcass. However, estimated average daily energy deposited in the soft tissues of the carcass during the feedlot phase and the efficiency of gross energy utilization were higher ($P < .02$) for steers fed during the warm period.

INTRODUCTION

Florida ranks sixteenth among the states in the United States in total number of cattle and calves and ninth in number of beef cows. Florida is a net exporter of feeder cattle and a net importer of fed beef. It is estimated that over 80% of the fed beef consumed in Florida is finished out of state.

The successful establishment of a Florida feedlot industry, adequate to provide the amount of quality beef consumed in Florida, will require the development of efficient, year-round beef finishing, slaughtering and marketing systems. Also required will be an economical source of energy and protein feedstuffs and appropriate breed types which are well adapted for finishing in both the hot and cool periods of the year.

Corn grain is the principal ingredient of Florida feedlot diets. Only 5% of the corn fed by Florida feedlots is produced in the state; 95% has to be imported from other states. The fact that corn production in Florida is not approaching consumption demands indicates that another source of energy should be studied.

The addition of fat to diets for finishing cattle would reduce the requirement for corn grain as an energy source. In addition to being a source of energy, fat also improves the color, texture and consistency of many feedstuffs.

Research has shown that the efficiency of converting feed to gain might be improved by the addition of fats and oils to the diet. A unit of fat has approximately 2.5 times as much gross energy as a unit of carbohydrate, thus, the addition of fats to the diets of feedlot cattle might alleviate part of the depressed performance observed in feedlot cattle during the hot, humid summer period in Florida.

A large percentage of cattle produced in Florida has some Brahman breeding. An evaluation of the feedlot performance of different breed types of cattle, in both the cool and hot periods of the year, is needed to determine the most satisfactory breeding programs and also to determine the best finishing system for the different breed types.

The present study was designed to evaluate

1. the substitution of fat for corn as a source of energy in diets for finishing cattle,
2. the feedlot performance of European crossbred versus Brahman crossbred steers during the cool and hot periods of the year in Florida, and
3. the effect of diet, breed type and feeding period on carcass characteristics.

LITERATURE REVIEW

Feedlot Performance

Effect of Fat Added to Diet

Nutritionally, there has never been any reason to question the merit of fat as an ingredient in the diet of animals. Fats are energy-rich, highly digestible and palatable. The addition of fat also improves the color and textures of many feeds, making them look "richer" and feel more moist (Rice et al., 1954). Tests have proven that fats are approximately $2\frac{1}{2}$ times as rich in calories as corn, and on that basis have a value of at least $2\frac{1}{2}$ times the cost of corn. In view of the advantages of including fat in feeds, it would seem that this material would be a rather valuable feedstuff.

The feeding of fats offers a method for increasing energy consumption by finishing cattle. Willey et al. (1952) reported that the addition of 5% cottonseed oil to a diet for finishing steers resulted in a markedly beneficial effect on the efficiency of feed utilization (11%), but no improvement in rate of gain. However, Hentges et al. (1954) fed a diet containing 5% of raw tallow to fattening steers and increased the rate of gain by 28%. The steers that received the fat added diet also required less feed per unit of gain. In a second trial, the authors noted that 5% added fat had little effect (5.5%) while 10% added fat reduced the rate of gain by 17%.

In similar experiments, Matshushima and Dowe (1954) and Roberts and McKindy (1964) did not find any effect on feed efficiency or rate of gain when they fed steers with 5% of tallow in the diet.

Matshushima and Dowe (1954) also fed steers a diet with 15% of corn oil and found a decrease in rate of gain and feed efficiency. Bohman et al. (1957) compared three levels of added fat (0, 5 and 10% of a mixed fat which was predominantly inedible fat). The steers fed 5% fat gained 28% faster than those fed the 0% level. However, the addition of 10% fat was not as effective. Both the 5% and 10% levels of added fat decreased by 23 and 16%, respectively, the amount of feed required per kg of gain. The authors reported no palatability problems with any of the diets, and fat had no significant effect on feed consumption. A similar experiment was conducted by Marchello et al. (1971). The steers were fed four levels of added fat (0, 5, 10% and 15%) during a 140-day feeding period. The animals fed the 0, 5 and 10% levels of fat performed similarly; however, the performance of the steers fed the 15% fat diet was poor. This group of steers gained about 50% less weight and required about 27% more feed per unit gain than the other three groups. The substitution of 5% of animal fat for 5% of yellow corn to diets of finishing steers was reported by Wise et al. (1963) and Bradley et al. (1966). The authors reported that the substitution of 5% fat for 5% corn did not have a significant effect on rate of gain or feed efficiency.

In a study involving the substitution of 5% molasses and 1% urea by 5% soybean oil and 1% cracked corn, Putnam et al. (1969) reported a decrease in average daily gain, feed intake and feed efficiency. The

authors stated that the addition of 5% of soybean oil to corn-based finishing diets depressed animal performance. However, Farlin et al. (1978) noted that inclusion of 5% fat, replacing 5% high moisture corn, to the diet for finishing bulls did not alter average daily gain, but bulls fed 5% fat in their diet consumed 6% less feed than those fed the no fat diet.

Clapperton and Steele (1983) conducted an experiment in which different amounts of tallow were added to a barley-based concentrate and offered to cows together with a good quality grass silage. When up to 750 g tallow per day were added, silage dry matter intake increased from 7.6 to 8.2 kg/d; however, when the amount of tallow was increased to 940 g/d, silage dry matter intake decreased to 7.9 kg/d and the total feed intake was reduced by 7% when compared with the control diet. In another study, Clapperton and Steele (1983) added 450 g of soybean oil per day to a basal diet of grass silage supplemented with soybean meal. When the oil was substituted for part of the meal, the total feed intake was reduced by 13%, but when soybean oil was added to the soybean meal, total feed intake was reduced by only 9%.

Scott et al. (1971) reported the possibility of manufacturing high-fat supplements for ruminants in which the fats are protected from action of the ruminal microflora by encapsulation within a formaldehyde-protein complex. Cuitun et al. (1975) described the procedure for producing the formaldehyde-protein complex protected fat. The protected fat product contained equal amounts of casein and fat. Garrett et al. (1976) compared four levels of fat, 10 and 21% of protected sunflower oil and 6 and 10% of protected animal tallow, for

finishing steers. The steers were fed for 115 days. Those fed the 10% protected tallow diet consumed less feed than the other groups. The average daily gain for steers receiving 6% protected tallow diet was 10% above that of those fed the basal diet. No difference was found among the diets for feed efficiency.

McCartor and Smith (1978) fed steers a diet containing 14% of protected tallow during a 56-day feeding trial. Average daily gain of steers fed the protected tallow was 19% higher than that of steers fed the control diet. The authors also reported that steers fed the protected tallow consumed 34% less feed per unit of gain than the steers fed the control diet.

McCartor et al. (1979) reported that feeding steers with protected tallow increased gains by 6% in a 118-day feeding period. The addition of 8% of protected tallow to the diet did not affect feed intake. In a study conducted by Haaland et al. (1981), 180 steers were fed for a 111-day feeding period to compare diets containing 0, 5 and 10% of protected tallow. The diets were formulated to contain equal amounts of metabolizable energy. Steers fed the 5% added fat diet had a higher average gain and a corresponding better feed efficiency than steers fed the 10% added fat diet and those fed the control diet. Average daily gains of steers fed the control diet were not different from the gains of those receiving 10% of protected tallow.

The feeding of fat offers a method for increasing the efficiency of feed utilization and daily weight gain of fattening cattle. However, the effect of added fat in the diet on the performance of finishing cattle seems to depend on the type of fat used (vegetable or

animal and protected or unprotected), the way in which it is added and the amount of fat used.

Period of Feeding

Wide variability in climatic conditions, dietary factors, housing systems and other environmental factors results in great variation in feedlot performance of cattle (Muhamad et al., 1983). Few reports are available describing the effects of climate on finishing cattle. Ray et al. (1969), in work done at the Yuma Substation, Arizona, reported that winter-fed cattle performed significantly better than summer-fed cattle. However, Riggs (1966), working at various locations in the southern part of Texas, reported that feedlot performance was not significantly different among groups of cattle fed under differing climate conditions. Kappel et al. (1972), in work conducted at Louisiana State University, Baton Rouge, examined the effects of season on feedlot performance of feedlot steers. They found that the effects of seasons were significant, but were not consistent over years. The authors reported that the lack of consistency among the results obtained may have been due partially to differences in the productive potentials of the groups of cattle used in the experiments.

Muhamad et al. (1983), in work done at Iowa State University, reported that average daily gain for steers fed during the summer was higher than that for steers fed in the winter. They did not find differences in feed efficiency between steers fed in the summer and those fed in the winter.

Heat increment of digestion (heat produced from eating, rumination, and fermentation) is large in ruminants; thus, reduced feed intake due to increasing environmental temperature and humidity

causes a decrease in heat production (Sharma and Kehar, 1961). Hoffman and Self (1970), in work conducted at Iowa State University, observed that steers tended to consume more feed per day in the winter than in summer. However, Schake et al. (1978), in work done in central Texas, and Muhamad et al. (1983), in Iowa, did not find differences in dry matter intake for steers fed during the summer and winter seasons. Schake et al. (1978) fed steers in confinement barns and found that season of year influenced daily gain and feed efficiency. Cattle placed on feed in the spring gained more slowly and were less efficient than those started on feed in the fall.

Period and Diet Interaction

There is evidence to show that in a hot environment a diet with a low fiber content has a beneficial effect on the animal's thermal balance and hence on its production (Bianca, 1965). Moose et al. (1969) reported that the heat increment of high fiber diets may alter ration utilization and animal performance under warm and cool conditions. Leighton and Rupel (1960), in work done at College Station, Texas, observed that in warm weather a diet high in protein and low in fiber tended to keep body temperature, respiratory rate and heart rate low.

In a two season study, Muhamad et al. (1983) noted that steers fed high and low energy diets were not different in weight gain during the winter season. However, during the summer season steers fed a high-grain (high energy) diet had higher average daily gains than those fed a low-grain (low energy) diet. The steers fed a high energy diet in the summer did not differ in average daily gain from those fed a medium energy diet.

Bohman et al. (1959) reported that the addition of animal fat to the diet had no effect on the weight gains of beef steers fed in the winter and summer seasons.

Period and Breed Interaction

Brahman and Brahman crossbred cattle are more heat tolerant than cattle of the British breeds (Damon et al., 1961). Ittner et al. (1954) and Rollins et al. (1964), in work done in Imperial Valley, California, observed that Hereford-Brahman steers had more rapid feedlot gains than Hereford steers during the summer but the reverse was true during the fall and winter.

Brahman crossbreds are better adapted to the summer than to the winter environment (Cundiff, 1970). Either the climatic or nutritional environment, or possibly both, may be involved in contributing to the apparent difference in relative adaptability of Brahman crosses.

Cartwright (1955) reported that Brahman-Hereford crossbred heifers had higher summer gains on pasture than either straightbred Hereford or Brahman heifers. However, Kappel et al. (1972), in work done in Louisiana, reported that season x breed interactions were not significant for feedlot performance traits. They reported that Hereford and Brahman-Hereford crossbred steers had good performance during the summer and the magnitude of the differences between the two breed groups was approximately the same in both summer and winter.

Colditz and Kellaway (1972) reported that at 38 C Brahman-Friesian crossbred steers ate more than Friesian steers but at 17 C no difference was found for the intake of the two breed groups. They also found that Brahman-Friesian crossbred steers gained more weight

than Friesian at 38 C, but that the two breed groups did not differ in average daily gain at 17 C.

Bianca (1965) reported that the environmental temperatures at which feed intake begins to decline was 27 C in Brown Swiss heifers and 35 C in Brahmans.

Effect of Added Fat on Digestibility

Digestion studies to determine the influence on nutrient digestibility of fat added to the diet was first conducted by Lucas and Loosli (1944). They found that digestible ether extract and total digestible nutrients were higher for the diet with added fat than for the diet without fat. The authors also reported that these differences were attributable solely to the difference in fat content. There was no effect on the apparent digestibility of the other nutrients. These findings were corroborated by those of Swift et al. (1948), who added fat to diets for sheep; Erwin et al. (1956), who added 7% animal fat to diets for steers and sheep; Ward et al. (1957), who added 3.5% corn oil to diets for sheep; and Kenneth and Woods (1963), who added 5% corn oil in one diet and 5% fatty acids in another diet for sheep.

Erwin et al. (1956) indicated that the addition of 7% animal fat to diets for finishing steers and sheep reduced the digestibility of dry matter and crude fiber of a high-fiber diet. The authors reported that the mode of action of fat in reducing the digestibility of certain nutrients in the ration had not been established. A possibility exists that the depressing effect is physical, that is, by coating the fiber (cellulose). Similar findings were reported by Ward et al. (1957) and Kenneth and Woods (1963). Brethour et al. (1958)

found that high levels of either animal or vegetable fat depress the digestibility of most ration components. They also indicated that 15% added fat to high-fiber diet for sheep reduced the digestibilities of dry matter and organic matter by 29% and 25%, respectively. Bohman and Lesperance (1962) fed steers a high-fiber diet containing 250 g animal fat per head daily. They reported that dietary fat increased the digestibility of ether extract (44.7% versus 81.3%) and NFE (65.2% versus 67.7%), decreased the digestibility of fiber (64.1% versus 57.6%), increased the percentage of total digestible nutrients (59.5% versus 63.9%), but had no effect on percent digestible energy. The authors found more soaps present in the feces from the fat-fed cattle (2.35% versus 3.66%). When fat is added to a low quality roughage diet, digestibility usually is reduced (Erwin et al., 1956; Ward et al., 1957; Brethour et al., 1958; Bohman and Lesperance, 1962; Kenneth and Woods, 1963).

The effect of adding different fats, animal and hydrolyzed vegetable and animal, to a high concentrate diet for finishing steers was studied by Grant et al. (1963). They reported that the addition of 4% fat to the diet tended to improve the digestibility of dry matter, crude protein, crude fiber and gross energy. These increases, however, were not significant. There was an increase in ether extract digestibility, total digestible nutrients and digestible energy due to fat addition. Johnson and McClure (1972) fed lambs different high energy diets containing either 6% fat from corn oil, 5% hydrolyzed animal and vegetable fat, or 8% hydrolyzed animal and vegetable fat. They reported that the addition of either 6% fat from corn oil or 6% fat from hydrolyzed animal and vegetable fat to the high concentrate

diet did not affect the digestibilities of dry matter, crude fiber and crude protein.

Cuitun et al. (1975) fed steers different diets containing either 6% protected sunflower oil, 12% protected casein-sunflower oil or 6% unprotected sunflower oil. They reported that the highest dry matter, gross energy, ether extract and protein digestibilities of the diets were by steers fed 12% protected casein-sunflower oil and the lowest for those fed the diet with 6% unprotected sunflower oil. A similar study was conducted by Haaland et al. (1981). They fed high levels of protected tallow, 25% and 37.5%, in high energy diets for finishing steers. The authors reported that the digestibility of dry matter and neutral detergent solubles were decreased by both levels of protected tallow.

Carcass Characteristics

Effect of Fat Added to Diet

The effect on carcass characteristics of adding fat to the diet for finishing steers was first reported by Willey et al. (1952). Steers which received 5% cottonseed oil in the diet had a lower percentage of fat and a higher percentage of lean in the rib cut than those fed the no fat diet. Later, Stiles et al. (1974) and Farlin et al. (1978) reported similar results. They found that steers fed diets with fat added had a lower percentage of fat in the rib cut and, therefore, an increase in percentage of lean. Bohman et al. (1957), Edwards et al. (1961) and Putnam et al. (1969) did not find differences in separable fat in the rib cut due to feeding fat to steers. However, McCartor et al. (1979) added protected fat to the

diet and found an increase in the percentage of fat in the rib cut of steers.

Willey et al. (1952) reported that steers fed the no fat diet had lighter, more desirable colored ribeyes and higher marbling scores than those fed the fat added diet. Later, Bohman et al. (1957) and Putnam et al. (1969) reported that steers fed diets containing either 5% or 10% animal or 5% soybean oil did not differ in amount of marbling from those fed the no fat diet. However, Farlin et al. (1978), in agreement with Willey et al. (1952), reported that a lower marbling score was associated with feeding 5% of animal fat to finishing steers.

Edwards et al. (1961) studied two levels of animal fat, 2.5 and 5%, added to diets for finishing steers. Total saturated fatty acids increased in the rib fat sample as fat level in the diet increased. Similar findings were reported by Willey et al. (1952), Tove and Matrone (1963) and Church et al. (1967). They noted that steers fed fat added diets had more saturated fatty acids in the rib cut than those fed no fat diets. Edwards et al. (1961) reported a significant increase in stearic acid content in the rib fat of steers fed the fat added diets. Skelley et al. (1973) found a correlation of $-.43$ between marbling and percentage of saturated fatty acids. They also reported that stearic and palmitic acids tended to decrease as marbling score increased, whereas oleic and linoleic acids had the reverse trend.

Polyunsaturated fatty acids normally are hydrogenated by microorganisms in the rumen (Scott et al., 1971). Because of this hydrogenation, triglycerides of ruminants contain very low proportions

of polyunsaturated fatty acids (Noble, 1978). Scott et al. (1971) fed sheep different diets containing either unprotected sunflower oil or formaldehyde protected sunflower oil. The authors reported that lambs fed a protected sunflower oil diet had higher percentage of polyunsaturated fatty acids in depot fat (73.0%) than those fed unprotected sunflower diet (54.2%).

Garrett et al. (1976) fed steers diets with protected tallow, 15 and 25%, and protected vegetable oil, 15 and 30%. They found that the addition of protected fat to the diet did not affect carcass weight, yield grade, fat thickness or ribeye area. However, the addition of protected fat increased the marbling score and decreased the level of saturated fatty acids in the rib cut. Haaland et al. (1981) also found that addition of protected fat to the diet tended to increase the marbling score in steers. McCartor et al. (1979) fed steers with protected tallow and found that those fed the diet containing protected tallow had a higher adjusted fat thickness, more kidney, pelvic and heart fat and a poorer yield grade than those fed the no fat diet. Putnam et al. (1969), Garrett et al. (1976), McCartor et al. (1979), and Haaland et al. (1981) reported that steers fed diets containing 10 to 14% of protected tallow had a smaller ribeye area than those fed a no fat diet. Rhodes et al. (1978) observed a reduction in skeletal growth of heifers fed a protected fat diet, even though the heifers became fatter and gained more weight than those fed a control diet.

Skelley et al. (1973) reported that adding fat to the diet of finishing steers did not alter Warner-Bratzler shear values or sensory tenderness. Likewise, the authors reported that the percent total

saturated fatty acids, percent total unsaturated fatty acids and individual fatty acids did not affect the Warner-Bratzler shear value or sensory tenderness. McCartor et al. (1979) did not find any difference in sensory panel evaluation or Warner-Bratzler shear values between carcasses from steers fed diets including protected tallow and those fed a control diet with no fat added.

Willey et al. (1952), Stiles et al. (1974) and Farlin et al. (1978) found that steers fed diets with fat added had a lower percentage of fat in the rib cut and, therefore, an increase in percentage of lean. However, Bohman et al. (1957), Edwards et al. (1961) and Putnam et al. (1969) did not find differences in separable fat in the rib cut due to feeding fat to steers.

Effect of Breed Type

The possibility that breeding influences carcass composition was suggested by Carroll et al. (1955) when they recognized that Brahman-Hereford crossbred steers had higher bone and lean percentages and a lower fat percentage in the carcass than Hereford steers. Breed differences for carcass traits have been reported by Ramsey et al. (1963), Cole et al. (1964), Rollins et al. (1964), Moran (1970), and Kappel et al. (1972). Thompson and Barlow (1981) reported that, when slaughtered at the same liveweight, Brahman-Hereford crossbreds had heavier carcasses than Hereford steers. They also noted that the two breed groups, at the same carcass weight, did not differ in percent kidney fat, ribeye area, kilograms of subcutaneous and intermuscular fats, or kilograms of muscle and bone.

Cole et al. (1964) compared Angus, Hereford and Brahman-British crossbred steers. They reported that Angus and Hereford steers were

fatter and had shorter carcasses than the Brahman crossbreds. Angus steers had a higher marbling score and a higher percentage of kidney fat than Hereford and Brahman-British crossbred steers. The Hereford and Brahman crossbred steers did not differ in marbling score. Similar results were reported by Cundiff et al. (1982), when they compared Hereford-Angus crossbred steers with Brahman-British crossbreds. The authors noted that Hereford-Angus crossbreds had a higher marbling score, lighter carcass weight and a higher percent kidney fat than the Brahman crossbreds. Peacock et al. (1979) reported that effects of Brahman breeding were negative for ribeye area and quality grade. Peacock et al. (1979) and Peacock et al. (1982) noted that Angus steers had a larger ribeye area than Brahman-Angus crossbreds. However, Cole et al. (1964), Moran (1970) and Thompson and Barlow (1981) did not find differences for ribeye area when they compared Hereford and Brahman-Hereford crossbred steers.

Ramsey et al. (1963) studied the influence of breed type on meat quality. They reported that Hereford, Angus and Brahman-British crossbreds did not differ in tenderness, juiciness or flavor scores. Similar results were reported by Cole et al. (1964). They compared the effect of breed type, Angus Hereford and Brahman-British crossbred, on tenderness, flavor and juiciness. The authors reported that straightbred British and the Brahman-crossbreds did not differ for flavor, juiciness or tenderness; however, the shear value was higher for Angus steers than for Herefords and Brahman-British crossbreds. Carroll et al. (1964) found that loin steaks from Hereford steers were more tender but had lower juiciness scores than

those from Brahman-Hereford crossbred steers, but did not differ in flavor.

Brahman-British crossbred steers became less tender as the percentage of Brahman blood increased (Kincaid, 1962). Cundiff (1970) reported that tenderness, as measured by Warner-Bratzler shear force value, was less in Brahman-British crossbreds than in cattle of the British breeds.

Cole et al. (1964) found that British steers had a higher percentage of ether extract and a lower percentage of protein and moisture in the soft tissue of the carcass than did Brahman-British crossbred steers.

EXPERIMENTAL PROCEDURE

Forty-seven crossbred steers were used to study the effects of added fat in the diet (control versus fat added), breed type (European crossbred and Brahman-European crossbred) and period of year (cool versus warm) on feedlot performance and carcass characteristics. Twenty-five of the steers were placed in the feedlot on December 21, 1982, and 22 of the steers were placed on a backgrounding program of rye-ryegrass and clover pastures and/or fed corn silage on bahiagrass pastures during the winter. The backgrounded steers were placed in the feedlot on July 14, 1983. The feedlot and digestibility phases of this study were conducted at the Beef Research Unit from December 21, 1982, through November 6, 1983. The Beef Research Unit is located 12 miles north of Gainesville, at latitude 29°40'N, and the climate is classified as semitropical.

Breed Type

Steers calves, approximately 10 to 11 months of age, were purchased from two ranches in central Florida. The steers were selected to be representative of two crossbreds types commonly found in Florida, i.e., crossbreds mostly of European breeds and crossbreds of about one-half Brahman one-half European breeding. Both crossbred types were purchased from each of the ranches. Forty-seven steers were used in the feedlot, eight in the comparative slaughter and eight in the digestion trial phases of this study.

TABLE 1. AVERAGE MAXIMUM AND MINIMUM MONTHLY TEMPERATURES AND PRECIPITATION AT THE BEEF RESEARCH UNIT DURING THE COOL AND WARM FEEDLOT PERIODS

Period	Temperature (C)			Precipitation (mm)
	Avg maximum	Avg minimum	Avg	Total
Cool 1982-1983				
Dec	23	9	16	35
Jan	17	2	9	82
Feb	18	4	11	112
March	22	6	14	182
April	25	6	15	163
May	26	12	19	80
Avg	22	7	14	
Warm 1983				
June	28	14	21	141
July	33	15	24	94
Aug	33	15	24	224
Sept	28	14	21	190
Oct	28	14	21	61
Nov	25	14	19	16
Avg	30	15	22	

Period

The cool period feedlot phase of this study was conducted from December 21, 1982, through May 26, 1983, and the warm period feedlot phase from July 14 through November 6, 1983. The average minimum and maximum temperatures during each period are shown in table 1.

Diet

One-half of the steers of each crossbred type in each period was fed a control diet and the other one-half received a fat added diet in which fat comprised 4% of the diet. Composition of the diets and fatty acid composition of the fat added to experimental diet are shown in tables 2, 3 and 4.

Feeding and Management During the Feedlot Phase

All steers were fed in a concrete-floored confinement facility, divided into four pens 20 m long and 9.5 m wide. Eight Calan-Broadbent individual feeding doors were located in each pen. The feeders were covered by a shed (3 m) and about one-fourth of the pen was covered by a slotted shade. The pens were not cleaned, allowing a manure build-up in the pens. This provided a more comfortable footing for the steers and eliminated temperature extremes found for cleaned concrete. A limestone mound, about 30 cm high, was placed under the slotted shade in the center of the pen.

An adjustment period of about 14 days was used each period. During this time, the steers were fed the control diet and trained to use the feeding door system. Water and a complete mineral mixture were supplied ad libitum to all animals throughout the adjustment and experimental periods. The steers were fed once a day and the orts were weighed daily, before the steers were fed. The amount of feed

TABLE 2. INGREDIENT COMPOSITION OF EXPERIMENTAL DIETS,
ON AN AS FED BASIS

Ingredient	Diet	
	Control	Fat
Cottonseed hulls, %	12	12
High moisture corn, %	79	74
Protein pellets, %	4	4
Molasses, %	5	5
Fat, %		4
Soybean meal, %		1

TABLE 3. CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS, ON A DRY MATTER BASIS

Component	Diet	
	Control	Fat
Dry matter, %	75.96	77.01
Crude protein, %	10.54	11.02
Crude fiber, %	8.14	8.98
Ether extract, %	4.24	7.77
Nitrogen free extract, %	50.08	45.79
Ash, %	2.96	3.45

TABLE 4. FATTY ACID COMPOSITION OF FAT
ADDED TO EXPERIMENTAL DIET

Fatty acid	% of total Fatty acids
C 14:0	1.37
C 16:0	19.17
C 16:1	3.00
C 18:0	12.62
C 18:1	45.39
C 18:2	14.39
C 18:3	1.11
Saturated	33.16
Unsaturated	63.81
Unknown fatty acid	3.03

offered was increased gradually to keep the animals at maximum consumption. The diets were mixed three times per week.

Steers fed during the cool period were implanted with 36 mg of Zeranol at the beginning of the experiment and with Synovex-S 75 days later. Steers fed in the warm period were implanted 3 times with 36 mg of Zeranol during the background phase. They were implanted with Synovex-S at the beginning of the feedlot phase and reimplanted with Synovex-S 75 days later.

The steers were fed to an estimated outside fat thickness of about 1 cm. As the steers reached the designated endpoint, they were weighed at 7:30 AM at the Beef Research Unit and were shipped the same day to the University of Florida Meats Laboratory in Gainesville for slaughter and collection of carcass data. The steers received no feed on the day of shipping, and were slaughtered the following day after standing overnight with no intake other than water.

Carcass Evaluation

The steers were weighed at the University of Florida Meats Laboratory prior to slaughter. Routine slaughter procedures were followed. The gastrointestinal tract from each steer was cleaned of digesta for determination of empty body weight. The right side of each carcass was stimulated with 500 volts (AC) for 20, 2 sec impulses. The left side of each carcass was not stimulated and served as the control for Warner-Bratzler shear force determinations. The warm carcass and hide of each steer were weighed on the slaughter floor scale. Dressing percent, as used in this study, was calculated as

$$\left(\frac{\text{hot carcass weight, kg}}{\text{empty body weight, kg}} \right) \times 100.$$

The carcasses were chilled at 0 to 2 C for 24 h, weighed, both sides of each carcass ribbed, and the left side was graded for quality and yield by University of Florida personnel. The ranges of scores for certain carcass characteristics were lean color, 7 = very dark red and 1 = dark pink; lean texture, 7 = extremely coarse and 1 = very fine; lean firmness, 7 = extremely soft and 1 = very firm; and fat color, 4 = yellow and 1 = white.

A boneless 10 cm section of short loin, starting at the 13th rib, was removed from left side of each carcass. These samples were wrapped with an inner coat of saran wrap and an outer coat of polyethylene freezer paper. They were kept in a 0 to 2 C cooler until five days postmortem and then placed in a -15 C freezer until being cut into steaks for analyses. The short loin samples were cut into 2.54 cm thick steaks. Two steaks from the left side of each carcass were designated for sensory panel evaluation and one steak from the same side was used for Warner-Bratzler shear force determination.

Loin steaks were broiled using a Farberware Open-Hearth broiler. Steaks were turned at 50 C internal temperature and removed from the broiler at 70 C. Internal temperature was monitored using thermocouples attached to a recording potentiometer.

Samples removed from the steaks were evaluated by an 8-member trained sensory panel for flavor (8 = extremely intense to 1 = extremely bland), juiciness (8 = extremely juicy to 1 = extremely dry), tenderness (8 = extremely tender to 1 = extremely tough), and amount of connective tissue (8 = none to 1 = abundant). A minimum of 6 cores (1.27 cm diameter) were removed from a 2.54 cm thick steak, parallel to the muscle fiber orientation, for shear force determination, using a Warner-Bratzler shear device.

The 9-10-11 rib section from the left side of each carcass was removed, at 24 h postmortem, by the procedure outlined by Hankins and Howe (1946), vacuum packaged and stored at -15 C for subsequent physical separation and chemical analysis. The rib sections were physically separated after thawing at 2 C into lean, fat and bone. The soft tissue components, fat and lean, were ground and stored in a plastic bag at -15 C until analyzed for chemical composition by the procedures of AOAC (1980). The physical separation data and the chemical analyses of the fat and lean tissues were used to predicted carcass composition using equations developed by Hankins and Howe (1946).

Energy content of the carcass was determined by assuming the caloric values of fat to be 9.367 Mcal/kg of fat (Blaxter and Rook, 1953) and values of protein to be 5.686 Mcal/kg of protein in the carcass (Garrett, 1958).

Energy Deposited in the Soft Tissue of Carcass

Four steers, two of each breed type, selected to be representative of the two crossbred types, were slaughtered at beginning of each feedlot period. These will be referred to as comparative slaughter steers. The same procedures described previously were utilized to determine the energy content of the carcasses. The energy deposited during the feedlot phase was calculated by subtracting the amount of energy in the soft tissues of the comparative slaughter steers from the amount of energy in the soft tissues of the carcasses of the steers slaughtered at end of the feedlot phase.

Digestion Trial

Eight steers, four European crossbreds and four Brahman-European crossbred, averaging about 350 kg, were used in two digestion trials, from August 5 through October 6, 1983.

The steers were halter broken and kept in a pen for 20 days to allow them to adjust to the experimental diets. The steers were confined in the metabolism crates for 21 days (7 days for adaptation to the crate, 7 days for intake adjustment and the last 7 days for collection). Steers were fed ad libitum during the digestion trial. The animals were removed from the metabolism crates after completion of the collection period and kept in a pen to be adjusted to the other experimental diet. Steers fed the control diet in the first period received the fat added diet in the second period and vice versa. The same procedures described above were used in the second digestion trial. A total of 16 observations were recorded (4 steers of each breed type x 2 diets x 2 trials).

Representative samples of feed, orts and feces were collected daily and dried in an oven at 65 C. Dry samples of feed, orts and feces were ground and homogenized at the end of each digestion trial and analyzed for moisture, ether extract, nitrogen and crude fiber AOAC (1980). Gross energy content of feed, orts and feces was determined in an adiabatic bomb calorimeter. Apparent digestibility coefficients of nutrients and digestible energy content of the experimental diets were calculated using equations described by Schneider and Flatt (1975).

Statistical Analyses

Data were analyzed by least-squares, fixed model procedures using the Statistical Analysis System (SAS, 1979). The model used to analyze the feedlot performance and carcass characteristics included the main effects of period, breed type, diet and all possible interactions among the main effects.

The digestion trial data were analyzed by analysis of variance. The model used included the fixed main effects of trial, diet and breed type and the interaction of diet and breed type.

RESULTS AND DISCUSSION

Feedlot Performance

The overall means for initial and final weights, days on feed, average daily gain and feed efficiency for the steers in this study were 269 kg, 467 kg, 126 days, 1.59 kg and 5.18 kg DM/kg gain. The average daily gain and feed efficiency found for this study were similar to performance obtained in the midwestern feedlots as reported by Brethour (1976), but superior to results reported for cattle fed in Florida (Tritschler et al., 1981; Harris, 1981; Hargrove et al., 1983).

Diet

Least squares means, standard errors and probabilities for feedlot performance traits are presented in table 5. The substitution of fat for high moisture corn in the diet for finishing steers did not improve the feedlot performance traits. Steers fed the fat added diet had about the same average daily gain (1.59 kg) as those fed the control diet (no fat added)(1.58 kg). There was no difference ($P > .6088$) in the number of days required for steers on the two diets to reach the selected slaughter point of 1.0 cm outside fat. Steers fed the fat added diet were fed for 127 days versus 124 days for those fed the control diet.

The average final weight for steers fed the fat added diet (469 kg) did not differ ($P > .6397$) from that of those fed the control diet (465 kg). The addition of fat to the diet did not improve ($P > .7541$)

TABLE 5. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR FEEDLOT PERFORMANCE, BY DIET

Trait	Diet				P
	Control		Fat		
	LS Mean	SE	LS Mean	SE	
Number of steers	25		22		
Final wt., kg	465	± 6.85	469	± 7.39	.6397
Days on feed	124	± 3.62	127	± 3.90	.6088
Average daily gain, kg	1.58	± .05	1.59	± .05	.9538
Average daily dry matter intake, kg	8.11	± .16	8.18	± .16	.7541
Average daily dry matter, kg DM/w ^{.75}	.10	± .001	.10	± .001	.9631
Feed efficiency, kg DM/kg gain	5.17	± .11	5.19	± .12	.8961
Average daily gross energy intake, Mcal	38.90	± .73	40.84	± .78	.0777
Average daily gross energy intake, Mcal/w ^{.75}	.47	± .007	.49	± .007	.0842
Gross energy efficiency, Mcal/kg gain	24.8	± .54	25.9	± .55	.1664

average daily dry matter intake (8.18 versus 8.11 kg) or feed efficiency (5.17 versus 5.19 kg DM/kg gain). Average daily gross energy intake was higher ($P < .0777$) for steers fed the fat added diet (40.84 Mcal) than for steers fed the control diet (38.90 Mcal).

Since the digestion coefficients for energy were 67.69% and 69.43% for the control and fat added diets, respectively, (table A-1), steers fed the fat added diet had a higher ($P < .0088$) estimated average daily digestible energy intake (28.34 Mcal) than those fed the control diet (26.32 Mcal). The results for average daily gain and feed efficiency, in this experiment, are in contrast to those obtained by Willey et al. (1952), Hentges et al. (1954) and Bohman et al. (1957). They reported that the addition of 5% fat to the diet had a positive effect on rate of gain and feed efficiency. In agreement with the results found in this study, Matsushima and Dowe (1954), Wise et al. (1963) and Marchello et al. (1971) reported that the addition of 5% of fat to the diet of finishing steers had no effect on rate of gain or feed efficiency.

Digestion Trial

Apparent digestibility coefficient of the two diets fed are shown in table A-1. The digestible nutrient content of the diets was obtained by multiplying the digestibility coefficient of each nutrient by the content of that nutrient in the dry matter of the diets. Means and standard errors for the apparent digestible nutrient content of the two diets and the average daily intake of digestible dry matter and digestible energy by steers fed each diet are presented in table 6.

TABLE 6. APPARENT DIGESTIBLE NUTRIENT CONTENT OF THE DIETS AND AVERAGE DAILY INTAKE BY STEERS OF DIGESTIBLE DRY MATTER AND DIGESTIBLE ENERGY

Trait	Diet				P
	Control		Fat		
	Mean	SE	Mean	SE	
Number of steers	8		8		
Digestible dry matter, %	54.06 ± .75		54.46 ± .65		.5934
Digestible protein, %	6.79 ± 1.45		7.05 ± 2.27		.0150
Digestible fiber, %	3.47 ± .19		3.75 ± .31		.3423
Digestible ether extract, %	3.25 ± .12		6.59 ± .15		.0001
Digestible nitrogen free extract, %	38.84 ± .94		36.00 ± .68		.4427
Digestible energy, Mcal/kg dry matter	3.24 ± .08		3.46 ± .06		.0347
Average daily dry matter intake, kg	8.08 ± .25		7.62 ± .29		.0160
Average daily digestible dry matter intake, kg	4.39 ± .19		4.15 ± .16		.0159
Average daily digestible energy intake, Mcal	26.27 ± 1.33		26.40 ± 1.04		.7945

The addition of fat to the diet increased ($P < .0001$) digestible ether extract of the diet from 3.25% for the control diet to 6.59% for the fat added diet. The increase of digestible ether extract due to the addition of fat to the diet is in agreement with results reported by Erwin et al. (1956), Ward et al. (1957) and Kenneth and Woods (1963).

Digestible energy was higher ($P < .0347$) for the fat added diet (3.46 Mcal/kg dry matter) than for the control diet (3.24 Mcal/kg dry matter). The average daily dry matter intake by steers used in the digestion trial was higher ($P < .0177$) for those fed the control diet (8.08 kg) than for those fed the fat added diet (7.62 kg). Thus, digestible energy intake, Mcal/kg dry matter, for steers fed the fat added diet (26.40 Mcal/day) did not differ ($P > .7945$) from that of the steers fed the control diet (26.27 Mcal/day).

There was a difference in measurements of feed intake between steers used in the digestion trial and those in the feedlot portion of the study. The significantly higher daily dry matter intake of the control diet found in the digestion trial was not found under feedlot conditions. The number of steers in the digestion trial was small, and the length of time each steer received each of the diets was relatively short. It is possible, therefore, that the intake data for the digestion trial might have been different if the number of steers had been larger or if the length of time each diet was fed had been greater.

Breed Type

European crossbred and Brahman-European crossbred steers had a similar performance for feedlot trials. Least squares means and

standard errors for feedlot performance are presented in table 7. The European crossbred steers used in this experiment were classified as such, based on visual appraisal of external characteristics. Many of these showed some Zebu breeding but probably less than one-fourth. On the other hand, the Brahman crossbred steers showed characteristics indicating they were at least one-half Zebu and many of them may have had more than one-half Zebu breeding. The results for similar feedlot performance of European crossbred and Brahman-European crossbred are supported by Cole et al. (1964), Cundiff (1970) and Kappel et al. (1972).

Diet and Breed Type Interaction

Least squares means and standard errors for feedlot performance by diet and breed type combined are presented in table 8. Diet by breed type affected ($P < .0597$) average daily gain. Brahman-European crossbred steers fed the fat added diet had a tendency ($P < .1497$) to gain more rapidly (1.66 kg) than those fed the control diet (1.53 kg). However, European crossbred steers fed the control diet had a tendency ($P < .2073$) to gain faster (1.64 kg) than the European crossbred steers fed the fat added diet (1.51 kg). The breed type of steer by diet interaction approached significance for daily dry matter intake ($P < .1085$) and daily gross energy intake ($P < .1055$).

Feeding Period

Feeding period affected average daily gain ($P < .0637$), days on feed ($P < .0001$), final weight ($P < .0055$), average daily dry matter intake ($P < .0001$) and average daily gross energy intake ($P < .0001$). Steers fed during the warm period gained more rapidly (1.65 kg/d) than those fed during the cool period (1.52 kg/d). The number of days

TABLE 7. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR FEEDLOT PERFORMANCE, BY BREED TYPE

Trait	Breed type				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of animals	25		22		
Final wt., kg	471	± 6.85	469	± 7.39	.4430
Days on feed	126	± 3.62	125	± 3.90	.7996
Average daily gain, kg	1.60	± .05	1.58	± .05	.7640
Average daily dry matter intake, kg	8.19	± .15	8.10	± .16	.7098
Average daily dry matter, kg DM/w ^{.75}	.097	± .001	.098	± .001	.9368
Feed efficiency, kg DM/kg gain	5.21	± .11	5.15	± .12	.7075
Average daily gross energy intake, Mcal	40.1	± .73	39.6	± .79	.6843
Average daily gross energy intake, Mcal/w ^{.75}	.48	± .007	.48	± .007	.9597
Gross energy efficiency, Mcal/kg gain	25.5	± .54	25.2	± .59	.7317

TABLE 8. LEAST SQUARES MEANS AND STANDARD ERRORS FOR FEEDLOT PERFORMANCE, BY DIET AND BREED TYPE

Breed Diet Trait	Brahman-European crossbred				European crossbred			
	Control		Fat		Control		Fat	
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE
Number of animals	12		13		13		9	
Final wt., kg	463	± 9.93	479	± 9.44	466	± 9.44	460	± 11.38
Days on feed	128	± 5.24	125	± 4.98	121	± 4.98	129	± 6.00
Average daily gain, kg	1.53	± .07	1.66	± .06	1.64	± .06	1.51	± .08
Average daily dry matter intake, kg	7.97	± .22	8.40	± .21	8.25	± .21	7.96	± .25
Average daily dry matter, kg DM/w	.096	± .002	.099	± .002	.099	± .002	.096	± .002
Feed efficiency, kg DM/kg gain	5.29	± .16	5.13	± .15	5.05	± .15	5.25	± .19
Average daily gross energy intake, Mcal	38.23	± 1.06	41.94	± 1.00	39.56	± 1.00	39.73	± 1.21
Average daily gross energy intake, Mcal/w ^{.75}	.46	± .01	.49	± .01	.47	± 1.00	.48	± .01
Gross energy efficiency, Mcal/kg gain	25.4	± .79	25.6	± .75	24.2	± .75	26.2	± .90

TABLE 9. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR FEEDLOT PERFORMANCE, BY FEEDING PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of animals	25		22		
Final wt., kg	452	± 6.85	482	± 7.39	.0055
Days on feed	146	± 3.62	105	± 3.90	.0001
Average daily gain, kg	1.52 ± .05		1.65 ± .05		.0637
Average daily dry matter intake, kg	7.64 ± .15		8.65 ± .16		.0001
Average daily dry matter, kg DM/w ^{.75}	.10 ± .001		.10 ± .001		.6145
Feed efficiency, kg DM/kg gain	5.07 ± .11		5.30 ± .11		.1665
Average daily gross energy intake, Mcal	37.38 ± .73		42.36 ± .79		.0001
Average daily gross energy intake, Mcal/w ^{.75}	.47 ± .007		.48 ± .008		.5861
Gross energy efficiency, Mcal/kg gain	24.8 ± .54		25.9 ± .59		.1706

required for steers fed during the two periods to reach the selected slaughter endpoint of 1.0 cm outside fat was less ($P < .0001$) for steers fed during the warm period (105 days) than to those fed during the cool period (146 days). Average daily dry matter intake was higher for steers fed in the warm period (8.65 kg) than for those fed during the cool period of the year (7.64 kg). Average daily gross energy intake also was higher for steers fed during the warm period (42.36 Mcal) than for those fed during the cool period (37.38 Mcal). However, when the average daily dry matter and gross energy intakes were calculated as intake per unit of metabolic weight, no differences were found for dry matter intake ($P > .6145$) or gross energy intake ($P > .5861$) between steers fed during the cool and warm periods. Steers fed during the cool and warm feedlot periods were purchased at the same time and were the same age at purchase; thus, the steers fed during the warm period were approximately 150 days older than the steers fed during the cool period at the time they were started on the feedlot study. Initial weight was higher for steers fed during the warm period (309 kg) than for those fed during the cool period (230 kg). When initial weight, which was confounded with age, was added to the statistical model as a covariate, most feedlot performance trials were very similar for steers fed during the two feeding periods. There continued to be, however, a difference ($P < .0257$) in the number of days required for steers to reach the slaughter point.

Diet and Period Interaction

Least squares means and standard errors for feedlot performance traits by diet and season are shown in table 10. Steers fed the fat added diet during the cool period required more days on feed to reach

TABLE 10. LEAST SQUARES MEANS AND STANDARD ERRORS FOR FEEDLOT PERFORMANCE, BY DIET AND FEEDING PERIOD

Period Diet Intrait	Cool				Warm			
	Control		Fat		Control		Fat	
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE
Number of animals	14		11		11		11	
Final wt., kg	445	± 9.07	460	± 10.27	484	± 10.27	479	± 10.63
Days on feed	139	± 4.79	151	± 5.42	109	± 5.42	102	± 5.61
Average daily gain, kg	1.56	± .06	1.48	± .07	1.61	± .07	1.70	± .07
Average daily dry matter intake, kg	7.71	± .20	7.60	± .22	8.50	± .22	8.80	± .23
Average daily dry matter, kg DM/w ^{1/3}	.099	± .001	.094	± .002	.096	± .002	.100	± .002
Feed efficiency, kg DM/kg gain	4.98	± .15	5.15	± .17	5.36	± .18	5.24	± .17
Average daily gross energy intake, Mcal	37.6	± 1.00	37.2	± 1.05	42.64	± 1.05	42.1	± 1.16
Average daily gross energy intake, Mcal/w ^{1/3}	.47	± .009	.47	± .011	.46	± .11	.50	± .011
Gross energy efficiency, Mcal/kg gain	23.9	± .72	25.7	± .81	25.7	± .08	26.1	± .84

the slaughter endpoint (151 d) than did those fed the control diet (139 d). Less difference was observed in number of days on feed for steers fed the two diets during the warm period (102 d for fat added diet versus 109 d for control). The diet by period interaction affected ($P < .0554$) average daily dry matter intake per unit of metabolic weight. The intake of the control diet tended to be higher than that of the fat added diet during the cool period, but lower during the warm period. The diet by period interaction also affected ($P < .0536$) average daily gross energy intake per unit of metabolic weight. Gross energy intake per unit of metabolic weight was higher for steers fed the fat added diet during the warm period (.50 Mcal/kg $w^{.75}$) than for steers fed the control diet during the warm period (.46 Mcal/kg $w^{.75}$). However, steers fed the two diets consumed equal amounts of gross energy per unit of metabolic weight during the cool period (table 10).

Feeding Period and Breed Type Interaction

Period and breed type interactions were not significant ($P > .10$) for feedlot performance traits. Steers of both breed types gained faster during the warm period (1.69 kg/d for the Brahman-European crossbred and 1.62 kg/d European crossbreds) than those fed during the cool period (1.51 kg/d for Brahman-European crossbreds and 1.54 kg/d for European crossbred steers). Steers of both breed types fed during the warm period were older and heavier at beginning of the feedlot study than those fed during the cool period. Average daily gains usually are higher for backgrounded yearlings than for calves (Neumann, 1977). Least squares means and standard errors by feeding period and breed type are presented in table 11.

TABLE 11. LEAST SQUARES MEANS AND STANDARD ERRORS FOR FEEDLOT PERFORMANCE, BY BREED TYPE AND FEEDING PERIOD

Period Breed	Cool				Warm			
	Brahman-European crossbred		European crossbred		Brahman-European crossbred		European crossbred	
Trait	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE
Number of animals	13		12		12		10	
Final wt., kg	449	± 9.44	455	± 9.93	493	± 9.93	471	± 10.95
Days on feed	147	± 4.98	145	± 5.24	106	± 5.25	105	± 5.78
Average daily gain, kg	1.51 ± .06		1.54 ± .07		1.69 ± .07		1.62 ± .07	
Average daily dry matter intake, kg	7.68 ± .21		7.60 ± .22		8.70 ± .22		8.61 ± .24	
Average daily dry matter, kg DM/w ^{0.75}	.098 ± .002		.096 ± .002		.097 ± .002		.099 ± .002	
Feed efficiency, kg DM/kg gain	5.16 ± .15		4.98 ± .16		5.27 ± .16		5.32 ± .18	
Average daily gross energy intake, Mcal	37.57 ± 1.00		37.18 ± 1.06		42.60 ± 1.06		42.11 ± 1.16	
Average daily gross energy intake, Mcal/w ^{0.75}	.48 ± .01		.47 ± .01		.47 ± .01		.48 ± .01	
Gross energy efficiency, Mcal/kg gain	25.2 ± .75		24.4 ± .75		25.8 ± .79		26.1 ± .87	

Carcass Characteristics

Diet

Least squares diet means and standard errors are presented in tables 12, 13, and 14 for carcass characteristics and in table 15 for palatability attributes of loin steaks.

There was no difference ($P > .20$) in slaughter weight, empty body weight, dressing percent or hide weight between steers fed the fat added diet and those fed the control diet (table 12). There was a tendency ($P < .1424$) for steers fed the fat added diet to have more gastrointestinal tract fill (31.5 kg) than steers fed the control diet (26.8 kg). The lack of a difference between the two diets for weight characteristics measured at slaughter was expected since diet did not affect feedlot average daily gain ($P > .9538$) or final feedlot weight ($P > .6397$) (table 5).

Both USDA quality grade and yield grade were affected significantly by diets (tables 13 and 14). Steers fed the control diet had a better ($P < .0945$) yield grade (2.7) than steers fed the fat added diet (2.9). Sixty-eight percent (17 of 25) of the carcasses of steers fed the control diet had yield grades of 1 and 2, and 32% (8 of 25) graded yield grade 3. This compares to 45.5% yield grades 1 and 2, 50% yield grade 3 and 4.5% yield grade 4 carcasses from steers fed the fat added diet. Steers fed the control diet tended ($P > .1277$) to have a larger ribeye area (71.9 versus 67.9 cm²) and had a larger ($P < .0332$) ribeye area per 100 kg hot carcass (26.1 versus 24.5 cm²). Garrett et al. (1976), Farlin et al. (1978), McCartor et al. (1979) and Haaland et al. (1981) also reported a greater ribeye area per unit of hot carcass weight for steers fed a

TABLE 12. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SLAUGHTER WEIGHT, GASTROINTESTINAL TRACT FILL, EMPTY BODY WEIGHT, DRESSING PERCENT AND HIDE WEIGHT, BY DIET

Trait	Diet				P
	Control		Fat		
	LS Mean	SE	LS Mean	SE	
Number of animals	25		22		
Slaughter weight, kg	447	± 6.50	453	± 7.02	.5768
Gastrointestinal tract fill, kg	26.8 ± 2.15		31.5 ± 2.10		.1424
Empty body weight, kg	420	± 6.40	421	± 6.91	.9503
Dressing percent	65.7 ± .70		65.9 ± .75		.7354
Hide weight, kg	37.7 ± 1.68		37.7 ± 1.85		.9782

TABLE 13. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR YIELD GRADE FACTORS, BY DIET

Trait	Diet				P
	Control		Fat		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Hot carcass wt., kg	276	± 5.02	277	± 5.42	.8702
Fat thickness, cm	.97 ± .05		1.02 ± .06		.5838
Ribeye area, cm ²	71.9	± 1.76	67.9	± 1.90	.1277
Ribeye area/100,kg hot carc., cm ²	26.1	± .53	24.5	± .57	.0332
Kidney, pelvic and heart fat, %	2.2	± .13	2.1	± .14	.5232
Yield grade	2.7	± .10	2.9	± .11	.0945

TABLE 14. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR QUALITY GRADE FACTORS, BY DIET

Trait	Diet				P
	Control		Fat		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Overall maturity ^a	A ⁵⁹ ± 5.19		A ⁵⁵ ± 5.27		.6034
Marbling ^b	SI ⁸⁶ ± 12.69		SI ²⁰ ± 13.69		.0011
Quality grade ^c	14.9 ± .34		13.6 ± .37		.0117
Lean color ^d	4.1 ± .12		3.8 ± .13		.1268
Lean texture ^e	2.5 ± .11		2.4 ± .11		.4866
Lean firmness ^f	2.2 ± .16		2.5 ± .16		.1445

^a Evaluated on a 100 point scale, in units of 10, within a maturity score.

^b SI "slight," evaluated on a 100 point scale, in units of 10, within each marbling score.

^c 21 point scale where 13 = good⁻, 14 good⁰ and 15 = good⁺.

^d 7 point scale where 3 = light cherry red, 4 = cherry red, and 5 = moderately dark red.

^e 7 point scale where 2 = fine and 3 = moderately fine.

^f 7 point scale where 2 = firm and 3 = moderately firm.

TABLE 15. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR PALATABILITY CHARACTERISTICS OF LOIN STEAKS, BY DIET

Trait	Diet				P
	Control		Fat		
	LS	Mean SE	LS	Mean SE	
Number of steaks	25		22		
Flavor ^a	5.6 ± .09		5.7 ± .09		.5480
Juiciness ^b	5.3 ± .12		5.7 ± .12		.0290
Tenderness ^c	4.8 ± .19		5.2 ± .20		.1718
Connective tissue ^d	5.1 ± .18		5.5 ± .18		.1803
Warner-Bratzler shear value, kg ^e	7.8 ± .31		7.6 ± .34		.6733

^a8 = extremely intense; 1 = extremely bland.

^b8 = extremely juicy; 1 = extremely dry.

^c8 = extremely tender; 1 = extremely tough.

^d8 = none; 1 = abundant.

^ekg/1.27 cm core.

control diet than for those fed a fat added diet. The better carcass yield grade found in this study for steers fed the control diet was due to the fact that they had a larger ribeye area and slightly less outside fat (.97 cm for carcasses of steers fed the control diet and 1.02 cm for those fed the fat added diet), since hot carcass weights were practically equal for steers fed the two diets and percent kidney, pelvic and heart fat favored steers fed the fat added diet (table 13).

Adding fat to the diet negatively affected marbling score ($P < .0011$) and, thus, USDA quality grade ($P < .0117$). The average marbling score for the carcasses of steers fed the control diet was slight⁶⁶, whereas it was a slight²⁰ for those fed the fat added diet (table 14). Respective average quality grades were High and Low Good. The percentages of carcasses by grade were 68% Good and 32% Choice for steers fed the control ration and 45% Standard, 41% Good and 14% Choice for steers fed the fat added ration. Considering general price differentials between Choice and Good and Good and Standard grade carcasses, the different grade distributions of carcasses of steers fed the two diets represent a real economic disadvantage for adding unprotected fat to the ration for finishing steers. Similar negative effects on marbling score due to fat added to the diet of finishing steers were found by Willey et al. (1952), Farlin et al. (1978) and Haaland et al. (1981). Edwards et al. (1961), Tove and Matrone (1963) and Church et al. (1967) reported that the addition of unprotected fat to the diet for finishing steers increased the percentage of saturated fatty acids in samples of rib fat. This increase in saturated fatty acids may be associated with

lower marbling scores for steers fed fat added diets, since Skelley et al. (1973) reported a correlation of $-.43$ between amount of marbling and percentage of saturated fatty acids in depot fat.

The addition of fat to the diet tended ($P < .1268$) to lighten color of the lean (table 14). Carcasses of steers fed the fat added diet had an average lean color score of 3.8, whereas lean color score for carcasses of steers fed the control diet was 4.1. There was no significant difference between carcasses of steers fed the two diets in overall carcass maturity or texture of the lean.

The sensory panel rated loin steaks from steers fed the fat added diet as more juicy ($P < .0290$) than those from steers fed the control diet (table 15). The sensory panel tended ($P < .1718$) to classify the loin steaks from steers fed the fat added diet as more tender than the steaks from steers fed the control diet (5.7 and 4.8, respectively). This more favorable rating by the sensory panel of the loin steaks from steers fed the fat added diet may have been due to the fact that the steaks were more juicy, since there was no difference ($P > .6733$) in the Warner-Bratzler shear force values for steaks from steers fed the two diets (table 15).

Breed Type

Least squares breed type means and standard errors for slaughter, weight, gastrointestinal tract fill, empty body weight, dressing percent and hide weight are shown in table 16. Brahman-European crossbred steers had a heavier ($P < .0008$) hide weight (40.3 kg) than European crossbreds (35.1 kg). Slaughter weight was similar ($P > .4195$) for Brahman-European crossbred (454 kg) and for European crossbred (446 kg) steers. There was no difference ($P > .8534$) for

TABLE 16. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SLAUGHTER WEIGHT, GASTROINTESTINAL TRACT FILL, EMPTY BODY WEIGHT, DRESSING PERCENT AND HIDE WEIGHT, BY BREED TYPE

Trait	Breed Type				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of steers	25		22		
Slaughter weight, kg	454	± 6.50	446	± 7.02	.4195
Gastrointestinal tract fill, kg	29.5 ± 2.11		28.9 ± 2.15		.8534
Empty body weight, kg	424	± 6.40	417	± 6.91	.4485
Dressing percent	66.0 ± .49		65.6 ± .53		.5265
Hide weight, kg	40.3 ± 1.68		35.1 ± 1.85		.0008

gastrointestinal tract fill between the two breed types.

Brahman-European crossbred steers did not differ ($P > .5265$) for dressing percent (66.0%) from European crossbred (65.6%). There was no difference ($P > .4465$) for empty body weight between steers fed the two diets.

Least squares means and standard errors for USDA yield and quality grade factors are presented in tables 17 and 18. European crossbred steers had a similar ($P > .4079$) hot carcass weight (274 kg) to that of the Brahman-European crossbreds (280 kg). Fat thickness was not different ($P > .6210$) between the breed types. There was no difference ($P > .5500$) between the steers of the two breed types for ribeye area ($P > .9263$) or ribeye area per 100 kg hot carcass ($P > .5500$). The results found for ribeye area in this study were not in agreement with those reported by Peacock et al. (1979) and Peacock et al. (1982). They noted that Angus steers had a larger ribeye area than Brahman-Angus crossbreds. However, there were differences in carcass weight among the breed groups in their study. Cole et al. (1964), Moran (1970) and Thompson and Barlow (1981) did not find a difference in ribeye area between Hereford and Brahman-Hereford crossbred steers. Both breed types in this study had an average USDA yield grade of 2.8. Brahman-European crossbred steers, however, had less ($P < .0974$) kidney, pelvic and heart fat (2.0%) than European crossbred steers (2.3%). No differences ($P > .40$) were found between steers of the two breed types for USDA quality grade and for overall carcass maturity.

Least squares means and standard errors for sensory characteristics and shear value are presented in table 19. Flavor

TABLE 17. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR YIELD GRADE FACTORS, BY BREED TYPE

Trait	Breed Type				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Hot carcass wt., kg	280	± 5.02	274	± 5.42	.4079
Fat thickness, cm	1.02 ±	.05	.98 ±	.06	.6210
Ribeye area, cm ²	70.0 ±	1.76	69.8 ±	1.96	.9263
Ribeye area/100,kg hot carc., cm ²	25.0 ±	.53	25.5 ±	.57	.5500
Kidney, pelvic and heart fat, %	2.0 ±	.13	2.3 ±	.14	.0974
Yield grade	2.8 ±	.10	2.8 ±	.11	.8370

TABLE 18. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR QUALITY GRADE FACTORS, BY BREED TYPE

Trait	Breed Type				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Overall maturity ^a	A ⁵⁹ ± 5.06		A ⁵⁴ ± 5.40		.4986
Marbling ^b	SI ⁵⁶ ± 12.69		SI ⁵⁰ ± 13.69		.7391
Quality grade ^c	14.1 ± .35		14.5 ± .37		.4380
Lean color ^d	4.0 ± .12		4.0 ± .13		.9149
Lean texture ^e	2.4 ± .11		2.5 ± .11		.5449
Lean firmness ^f	2.4 ± .16		2.3 ± .16		.6744

^a Evaluated on a 100 point scale, in units of 10, within a maturity score.

^b SI "slight," evaluated on a 100 point scale, in units of 10, within each marbling score.

^c 21 point scale where 13 = good⁻, 14 = good⁰ and 15 = good⁺.

^d 7 point scale where 3 = light cherry red, 4 = cherry red, and 5 = moderately dark red.

^e 7 point scale where 2 = fine and 3 = moderately fine.

^f 7 point scale where 2 = firm and 3 = moderately firm.

TABLE 19. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SENSORY CHARACTERISTICS AND WARNER-BRATZLER SHEAR VALUES OF LOIN STEAKS, BY BREED TYPE

Trait	Breed Type				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of steaks	25		22		
Flavor ^a	5.6 ± .08		5.6 ± .08		.8430
Juiciness ^b	5.4 ± .11		5.7 ± .19		.0916
Tenderness ^c	4.8 ± .19		5.3 ± .20		.0856
Connective tissue ^d	5.6 ± .18		5.1 ± .19		.0757
Warner-Bratzler shear value, kg ^e	8.3 ± .31		7.0 ± .34		.0092

^a8 = extremely intense; 1 = extremely bland.

^b8 = extremely juicy; 1 = extremely dry.

^c8 = extremely tender; 1 = extremely tough.

^d8 = none; 1 = abundant.

^ekg/1.27 cm core.

score of loin steaks from steers of the two breed types was the same (5.6). Loin steaks from European crossbred steers were more juicy ($P < .0916$) than those from the Brahman-European crossbreds. Loin steaks from European crossbred steers were more ($P < .0856$) tender, as measured by sensory taste panel (5.3) than Brahman-European crossbreds (4.8). This result is supported by the Warner-Bratzler shear force value (table 19). European crossbred steers had lower ($P < .0092$) shear force value (7.0 kg) than Brahman crossbred steers (8.3 kg). The European crossbreds had more ($P < .0757$) connective tissue (5.1) than Brahman crossbreds (5.6). The findings in this study that steaks from steers of European breeding are more tender than those from cattle of Brahman breeding is in agreement with most research reported, including Thompson and Barlow (1981) and Peacock et al. (1982).

Diet and Breed Type Interaction

Least squares diet x breed type means are presented in tables 20 and 21 for carcass characteristics and in table 22 for palatability attributes of loin steaks.

The interaction of diet and breed type did not affect ($P > .12$) any of the carcass characteristics or palatability attributes evaluated in this study.

Feeding Period

Least squares feeding period means and standard errors for carcass characteristics and palatability attributes of loin steaks are presented in tables 23, 24, 25 and 26.

Steers fed during the warm period had a greater ($P < .0023$) slaughter weight (466 kg) than those fed during the cool period (434

TABLE 20. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SLAUGHTER WEIGHT, GASTROINTESTINAL TRACT FILL, EMPTY BODY WEIGHT, DRESSING PERCENT AND HIDE WEIGHT, BY DIET AND BREED TYPE

Breed Type Diet Trait	Brahman-European crossbred				European crossbred			
	Control		Fat		Control		Fat	
	LS	SE	LS	SE	LS	SE	LS	SE
Number of animals	12		13		13		9	
Slaughter weight, kg	445	± 9.43	463	± 8.96	449	± 8.96	443	± 10.80
Gastrointestinal tract fill, kg	27.7	± 3.16	31.3	± 3.00	25.9	± 3.00	31.9	± 3.61
Empty body weight, kg	418	± 9.28	431	± 8.82	424	± 8.82	411	± 10.63
Dressing percent	66.0	± .71	66.1	± .68	65.4	± .68	65.8	± .81
Hide weight, kg	40.3	± 1.38	40.2	± 1.33	35.1	± 1.31	35.1	± 1.58

TABLE 21. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR YIELD AND QUALITY GRADE FACTORS, BY DIET AND BREED TYPE

Breed Type Diet Trait	Brahman-European crossbred				European crossbred				P
	Control		Fat		Control		Fat		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of carcasses	12		13		13		9		
Hot carcass wt., kg	275	± 7.28	284	± 6.91	277	± 6.91	270	± 8.34	.2737
Fat thickness, cm	.94	± .08	1.09	± .08	1.00	± .08	.95	± .09	.2425
Ribeye area	72.5	± 2.5	67.5	± 2.42	71.3	± 2.42	68.2	± 2.92	.7290
Ribeye area/hot carcass wt., cm ²	26.39	± .76	23.68	± .72	25.86	± .72	25.16	± .87	.2036
Kidney, pelvic and heart fat, %	2.1	± .18	2.0	± .18	2.4	± .18	2.3	± .21	.8368
Yield grade	2.6	± .14	3.1	± .14	2.7	± .14	2.8	± .14	.1276
Marbling ^a	S1 ⁹⁰	± 18	S1 ²⁰	± 17	S1 ⁹⁰	± 17	S1 ³⁰	± 21	.9970
Quality grade ^b	14.8	± .50	13.3	± .48	15.1	± .48	13.8	± .57	.8204
Lean color ^c	4.1	± .17	3.9	± .16	4.2	± .17	3.8	± .19	.4885
Lean texture ^d	2.4	± .15	2.4	± .15	2.6	± .15	2.4	± .17	.6279
Lean firmness ^e	2.2	± .22	2.6	± .21	2.2	± .22	2.4	± .24	.6297

a S1 "slight," evaluated on a 100 point scale, in units of 10, within each marbling score.

b 21 point scale where 13 = good, 14 good and 15 = good.

c 7 point scale where 3 = light cherry red, 4 = cherry red, and 5 = moderately dark red.

d 7 point scale where 2 = fine and 3 = moderately fine.

e 7 point scale where 2 = firm and 3 = moderately firm.

TABLE 22. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SENSORY CHARACTERISTICS AND WARNER-BRATZLER SHEAR VALUES OF LOIN STEAKS, BY DIET AND BREED TYPE

Breed Type Diet Trait	Brahman-European crossbred				European crossbred				P
	Control		Fat		Control		Fat		
	LS	SE	LS	SE	LS	SE	LS	SE	
Number of steaks	12		13		13		9		
Flavor ^a	5.5 ± .12		5.7 ± .12		5.6 ± .12		5.6 ± .13		.5137
Juiciness ^b	5.2 ± .16		5.6 ± .16		5.5 ± .16		5.8 ± .18		.7262
Tenderness ^c	4.6 ± .27		5.0 ± .26		5.0 ± .27		5.5 ± .29		.9518
Connective tissue ^d	5.0 ± .26		5.2 ± .24		5.3 ± .26		5.8 ± .28		.5315
Warner-Bratzler shear values ^e , kg	8.2 ± .45		7.3 ± .43		8.4 ± .43		6.8 ± .52		.4733

^a8 = extremely intense; 1 = extremely bland.

^b8 = extremely juicy; 1 = extremely dry.

^c8 = extremely tender; 1 = extremely tough.

^d8 = none; 1 = abundant.

^ekg/1.27 cm core.

TABLE 23. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SLAUGHTER WEIGHT, GASTROINTESTINAL TRACT FILL, EMPTY BODY WEIGHT, DRESSING PERCENT AND HIDE WEIGHT, BY FEEDING PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of animals	25		22		
Slaughter weight, kg	434	± 6.5	466	± 7.01	.0023
Gastrointestinal tract fill, kg	31.2 ± 2.18		27.2 ± 2.34		.2204
Empty body weight, kg	403	± 6.40	438	± 6.91	.0006
Dressing percent	67.1	± .49	64.5	± .53	.0012
Hide weight, kg	39.2 ± 1.67		36.2 ± 1.85		.3673

TABLE 24. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR YIELD GRADE FACTORS, BY FEEDING PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Hot carcass wt., kg	270	± 5.02	283	± 5.42	.0994
Fat thickness, cm	.90 ± .05		1.09 ± .06		.0243
Ribeye area, cm ²	70.58 ± 1.76		69.16 ± 1.90		.5859
Ribeye area/100 kg hot carcass wt., cm ²	26.17 ± .53		24.38 ± .57		.0260
Kidney, pelvic and heart fat, %	2.2 ± .13		2.1 ± .14		.4681
Yield grade	2.7 ± .10		3.0 ± .11		.0514

TABLE 25. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR QUALITY GRADE FACTORS, BY FEEDING PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Overall maturity ^a	A ⁴⁰ ±	5.06	A ⁷⁴ ±	5.40	.0001
Marbling ^b	S1 ⁵⁸ ±	12.69	S1 ⁴⁸ ±	13.69	.6066
Quality grade ^c	14.5 ±	.35	14.1 ±	.35	.4380
Lean color ^d	3.7 ±	.12	4.3 ±	.13	.0019
Lean texture ^e	2.4 ±	.11	2.5 ±	.11	.4320
Lean firmness ^f	2.1 ±	.16	2.5 ±	.17	.0955

^a Evaluated on a 100 point scale, in units of 10, within a maturity score.

^b S1 "slight," evaluated on a 100 point scale, in units of 10, within each marbling score.

^c 21 point scale where 13 = good⁻, 14 good⁰ and 15 = good⁺.

^d 7 point scale where 3 = light cherry red, 4 = cherry red, and 5 = moderately dark red.

^e 7 point scale where 2 = fine and 3 = moderately fine.

^f 7 point scale where 2 = firm and 3 = moderately firm.

TABLE 26. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SENSORY CHARACTERISTICS AND WARNER-BRATZLER SHEAR VALUES OF LOIN STEAKS, BY FEEDING PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of steaks	25		22		
Flavor ^a	5.8 ± .08		5.4 ± .09		.0057
Juiciness ^b	5.6 ± .11		5.5 ± .10		.5283
Tenderness ^c	5.0 ± .19		5.1 ± .20		.5776
Connective tissue ^d	5.3 ± .18		5.3 ± .19		.9148
Warner-Bratzler shear values ^e , kg	8.2 ± .31		7.2 ± .34		.0365

^a8 = extremely intense; 1 = extremely bland.

^b8 = extremely juicy; 1 = extremely dry.

^c8 = extremely tender; 1 = extremely tough.

^d8 = none; 1 = abundant.

^ekg/1.27 cm core.

kg). This difference was to be expected, since steers fed in the warm period were older and heavier at the start of the feedlot period and gained weight more rapidly. Gastrointestinal tract fill was not different ($P > .2204$) between steers fed during the two periods. However, due to the difference in slaughter weight, empty body weight was higher ($P < .0006$) for steers fed during the warm period (438 kg) than for those fed during the cool period (403 kg). Steers fed during the cool period did not differ ($P > .3673$) in hide weight (39.2 kg) from steers fed during the warm period (36.2 kg).

Feeding period affected both USDA yield grade and quality grade (tables 24 and 25). Steers fed during the cool period had a better ($P < .0514$) yield grade (2.7) than those fed during the warm period (3.0). This difference in yield grade between periods was due to the fact that steers fed during the warm period had more ($P < .0243$) fat cover (1.09 cm) than steers fed during the cool period (.90 cm) and also had heavier hot carcass weights ($P < .0994$). Ribeye area per 100 kg hot carcass was higher ($P = .0260$) for steers fed during the cool period (26.17 cm²) than was for steers fed during the warm period (24.38 cm²). This significant difference for ribeye area per 100 kg hot carcass weight was due to the fact that steers fed during the warm period had a heavier hot carcass weight (283 kg) than those fed during the cool period (270 kg), because there was no difference ($P > .5859$) for ribeye area between steers fed the two periods (70.58 cm² for steers fed during the cool period and 69.16 cm² for those fed during the warm period). Kidney, pelvic and heart fat did not affect yield grade because it was very similar ($P > .4681$) for steers fed during the two periods.

Period of the year during which steers were fed did not affect marbling score ($P > .6066$) or USDA quality grade ($P > .4380$). Overall maturity was different ($P < .0001$) between steers fed the two periods; however, both groups were classified as A maturity (A^{40} for steers fed during the cool period and A^{74} for steers fed during the warm period). Steers fed during the warm period had a higher ($P < .0019$) score for lean color (4.3) than those fed during the cool period (3.7). This agrees with greater overall carcass maturity and chronological age for steers fed during the warm period. Steers fed during the warm period had a higher ($P < .0955$) lean firmness score (2.5) than the steers fed during the cool period (2.1). Lean texture was not different ($P > .4320$) for steers fed during the two periods.

Loin steaks from steers fed during the cool period had a higher ($P < .0057$) flavor score (5.8) than those from steers fed during the warm period (5.4). There was no difference ($P > .50$) as measured by sensory panel for juiciness, tenderness or connective tissue of steaks from steers fed during the two periods of the year. Loin steaks from steers fed during the warm period had a lower ($P < .0365$) Warner-Bratzler shear value (7.2) than those from steers fed during the cool period (8.2). The tenderness difference shown by shear force value was not detected by the sensory panel.

Diet and Period Interaction

Least squares period of feeding x diet means are presented in tables 27 and 28 for carcass characteristics and table 29 for palatability characteristics of loin steaks. Period of feeding x diet did not affect ($P > .16$) any of the carcass characteristics traits or palatability characteristics of steak loins in this study.

TABLE 27. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SLAUGHTER WEIGHT, GASTROINTESTINAL TRACT FILL, EMPTY BODY WEIGHT, DRESSING PERCENT AND HIDE WEIGHT, BY DIET AND FEEDING PERIOD

Period Diet Trait	Cool				Warm				P
	Control		Fat		Control		Fat		
	LS	SE	LS	SE	LS	SE	LS	SE	
Number of animals	14		11		11		11		
Slaughter weight, kg	427	± 8.61	442	± 9.75	468	± 9.75	463	± 10.09	.3230
Gastrointestinal tract fill, kg	27.3	± 2.88	35.0	± 3.76	26.2	± 3.26	28.1	± 3.38	.3710
Empty body weight, kg	400	± 8.47	407	± 9.60	441	± 9.60	435	± 9.93	.4824
Dressing percent	66.7	± .65	67.4	± .73	64.6	± .73	64.48	± .76	.5947
Hide weight, kg	39.7	± 1.99	38.6	± 1.87	35.7	± 2.16	36.7	± 2.06	.4696

TABLE 28. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR YIELD AND QUALITY GRADE FACTORS, BY DIET AND FEEDING PERIOD

Period Diet Trait	Cool				Warm				P
	Control		Fat		Control		Fat		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of carcasses	14		11		11		11		
Hot carcass wt., kg	267	± 6.64	274	± 7.53	285	± 7.53	280	± 7.79	.4405
Fat thickness, cm	.90	± .07	.89	± .08	1.03	± .08	1.15	± .09	.3795
Ribeye area	71.0	± 2.32	70.3	± 2.63	72.9	± 2.63	65.4	± 2.72	.1900
Ribeye area/hot carcass wt., cm ²	26.68	± .70	25.66	± .79	25.58	± .79	23.17	± .82	.3734
Kidney, pelvic and heart fat, %	2.2	± .17	2.3	± .19	2.3	± .19	2.0	± .19	.1627
Yield grade	2.6	± .13	2.7	± .14	2.8	± .14	3.1	± .15	.4081
Marbling ^a	S1 ⁹⁰	± 17	S1 ²⁵	± 19	S1 ⁸¹	± 19	S1 ¹⁵	± 20	.9727
Quality grade ^b	15.0	± .46	13.9	± .53	14.9	± .52	13.2	± .54	.5820
Lean color ^c	3.8	± .16	3.5	± .18	4.4	± .19	4.2	± .17	.7894
Lean texture ^d	2.5	± .14	2.3	± .16	2.5	± .17	2.5	± .15	.4320
Lean firmness ^e	1.9	± .21	2.3	± .23	2.4	± .24	2.6	± .23	.7204

^aS1 "slight," evaluated on a 100 point scale, in units of 10, within each marbling score.

^b21 point scale where 13 = good, 14 good and 15 = good.

^c7 point scale where 3 = light cherry red, 4 = cherry red, and 5 = moderately dark red.

^d7 point scale where 2 = fine and 3 = moderately fine.

^e7 point scale where 2 = firm and 3 = moderately firm.

TABLE 29. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SENSORY CHARACTERISTICS AND WARNER-BRATZLER SHEAR VALUES OF LOIN STEAKS, BY DIET AND FEEDING PERIOD

Period Diet Trait	Cool				Warm				P
	Control		Fat		Control		Fat		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of steaks	14		11		11		11		
Flavor ^a	5.8 ± .11		5.8 ± .13		5.3 ± .13		5.5 ± .12		.3984
Juiciness ^b	5.4 ± .15		5.7 ± .17		5.2 ± .18		5.7 ± .16		.6151
Tenderness ^c	4.9 ± .25		5.0 ± .28		4.8 ± .29		5.5 ± .27		.2550
Connective tissue ^d	5.3 ± .23		5.3 ± .26		5.0 ± .28		5.7 ± .26		.2744
Warner-Bratzler shear values, kg	8.0 ± .41		8.3 ± .47		7.5 ± .47		6.8 ± .49		.3415

^a8 = extremely intense; 1 = extremely bland.

^b8 = extremely juicy; 1 = extremely dry.

^c8 = extremely tender; 1 = extremely tough.

^d8 = none; 1 = abundant.

^ekg/1.27 cm core.

Period of Feeding and Breed Type Interaction

Least squares period by breed type means are presented in tables 30 and 31 for carcass characteristics and table 32 for palatability characteristics of loin steaks. There was no effect ($P > .14$) of the period by breed type interaction on slaughter weight, gastrointestinal tract fill, dressing percent or hide weight. The feeding period by steer breed type affected ($P < .0865$) empty body weight. Brahman-European crossbred steers fed during the warm period had a heavier empty body weight (450 kg) than the European crossbred steers fed during the warm period (427 kg), but had a lighter average empty weight when fed during the cool period.

Hot carcass weight, fat cover and kidney, pelvic and heart fat were not affected ($P > .18$) by the period and breed type interaction. The period of feeding by breed type interaction, however, did affect ($P < .05$) ribeye area, ribeye area per 100 kg hot carcass weight and yield grade. European crossbred steers fed during the cool period had larger ribeyes and larger ribeyes per 100 kg hot carcass weight than Brahman-European crossbreds fed during the same period. However, the breed type rankings for the two traits were reversed for steers fed during the warm period. Likewise, steers of the two breed types reversed rankings in the two periods for yield grade, following the same order as the ribeye size.

The interaction of breed type by period did not affect ($P > .4847$) carcass quality grade or any of the characteristics used to determine quality grade (table 31). Also, the interaction of breed type by period did not affect ($P > .3691$) any of the sensory characteristics or Warner-Bratzler shear force value for loin steaks (table 32).

TABLE 30. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SLAUGHTER WEIGHT, GASTROINTESTINAL TRACT FILL, EMPTY BODY WEIGHT, DRESSING PERCENT AND HIDE WEIGHT, BY PERIOD AND BREED TYPE

Period Breed	Cool				Warm				P
	Brahman-European crossbred		European crossbred		Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Trait									
Number of animals	13		12		12		10		
Slaughter weight, kg	431 ± 8.96		438 ± 9.42		477 ± 9.30		455 ± 8.80		.1486
Gastrointestinal tract fill, kg	32.7 ± 3.00		29.7 ± 3.15		26.3 ± 3.16		28.1 ± 3.48		.4469
Empty body weight, kg	399 ± 8.81		408 ± 9.28		450 ± 9.28		427 ± 10.23		.0865
Dressing percent	67.4 ± .68		66.7 ± .71		64.7 ± .70		64.4 ± .71		.5947
Hide weight, kg	41.7 ± 1.97		36.7 ± 1.88		38.9 ± 2.30		33.6 ± 1.95		.9259

TABLE 31. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR YIELD AND QUALITY GRADE FACTORS, BY PERIOD AND BREED TYPE

Period Breed Type	Cool				Warm			
	Brahman-European		European		Brahman-European		European	
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE
Trait	13		12		12		10	
Number of carcasses	13		12		12		10	
Hot carcass wt., kg	269 ± 6.9		273 ± 7.3		291 ± 7.3		275 ± 8.0	
Fat thickness, cm	.97 ± .08		.83 ± .08		1.06 ± .08		1.12 ± .09	
Ribeye area, cm ²	67.2 ± 2.42		74.0 ± 2.55		72.8 ± 2.55		65.5 ± 2.80	
Ribeye area/100 kg hot carcass wt., cm ²	25.12 ± .72		27.21 ± .76		24.95 ± .76		23.80 ± .84	
Kidney, pelvic and heart fat, %	2.1 ± .18		2.4 ± .18		2.0 ± .18		2.3 ± .20	
Yield grade	2.9 ± .14		2.5 ± .14		2.8 ± .14		3.1 ± .16	
Marbling ^a	S1 ⁵⁷ ± 17		S1 ⁵⁸ ± 18		S1 ⁵⁵ ± 18		S1 ⁴² ± 20	
Quality grade ^b	14.3 ± .48		14.6 ± .50		13.8 ± .50		14.3 ± .55	
Lean color ^c	3.7 ± .17		3.7 ± .17		4.3 ± .17		4.3 ± .17	
Lean texture ^d	2.4 ± .15		2.4 ± .15		2.4 ± .15		2.6 ± .17	
Lean firmness ^e	2.1 ± .21		2.2 ± .22		2.7 ± .22		2.4 ± .24	

a S1 "slight," evaluated on a 100 point scale, in units of 10, within each marbling score.

b 21 point scale where 13 = good, 14 good and 15 = good.

c 7 point scale where 3 = light cherry red, 4 = cherry red, and 5 = moderately dark red.

d 7 point scale where 2 = fine and 3 = moderately fine.

e 7 point scale where 2 = firm and 3 = moderately firm.

TABLE 32. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR SENSORY CHARACTERISTICS AND WARNER-BRATZLER SHEAR VALUES OF LOIN STEAKS, BY PERIOD AND BREED TYPE

Period Breed Type	Cool				Warm				P
	Brahman-European crossbred		European crossbred		Brahman-European crossbred		European crossbred		
Trait	LS	Mean	SE	LS	Mean	SE	LS	Mean	SE
Number of steaks	13			12			12		
Flavor ^a		5.8 ± .12			5.8 ± .12			5.4 ± .12	
Juiciness ^b		5.4 ± .16			5.7 ± .16			5.6 ± .18	
Tenderness ^c		4.6 ± .26			5.3 ± .27			5.2 ± .29	
Connective tissue ^d		5.0 ± .24			5.6 ± .26			5.5 ± .28	
Warner-Bratzler shear values ^e , kg		8.9 ± .43			7.5 ± .45			6.6 ± .50	

^a8 = extremely intense; 1 = extremely bland.

^b8 = extremely juicy; 1 = extremely dry.

^c8 = extremely tender; 1 = extremely tough.

^d8 = none; 1 = abundant.

^ekg/1.27 cm core.

Carcass Composition, Energy Deposition
and Efficiency of Energy Utilization

Diet

Least squares diet means and standard errors for estimated physical and chemical composition of carcasses are presented, respectively, in tables 33 and 34. Addition of fat to the diet did not alter ($P > .6048$) the percentages of separable lean, fat or bone in the carcass. Likewise, addition of fat to the diet did not affect ($P > .7812$) the estimated percentages of moisture, ether extract or protein in the soft tissues (fat and lean) of the carcasses. Thus, as would be expected, diet did not affect ($P > .1575$) the amount of estimated energy in the soft tissues of the carcass (table 35).

Total energy deposited in the soft tissues of the carcass during the feeding period (table 35) was calculated by subtracting the estimated total energy in the soft tissues of the carcasses at the beginning of the feedlot phase (comparative slaughter steers, table A-2) from the total energy in the lean and fat tissues of steers slaughtered at the end of each feedlot phase. Steers fed the fat added diet deposited an estimated 563.3 Mcal of energy in the carcass during the feedlot phase, as compared with a mean of 534.0 Mcal for steers consuming control diet. These means did not differ ($P > .3925$).

Energy efficiency, expressed as percent of gross energy consumed that was deposited in the fat and lean tissues of the carcass, did not differ ($P > .8013$) between the two diets (table 36). Although steers consuming the fat added diet had a greater ($P < .0777$) average daily gross energy intake than did steers fed the control diet, they also had tendency to deposit slightly more energy in the carcass (4.7 Mcal/d versus 4.4 Mcal/d).

TABLE 33. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED PHYSICAL COMPOSITION OF THE CARCASS, BY DIET

Trait ^a	Diet				P
	Control		Fat		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Separable lean, %	56.0 ± .66		55.5 ± .71		.6048
Separable fat, %	29.1 ± .82		29.6 ± .88		.6885
Separable bone, %	15.9 ± .31		15.9 ± .34		.9760

^aPredicted using equation developed by Hankins and Howe (1946).

TABLE 34. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CHEMICAL COMPOSITION OF SOFT TISSUES OF THE CARCASS, BY DIET

Trait ^a	Diet				P
	Control		Fat		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Moisture, %	54.7 ± .68		54.5 ± .74		.8445
Ether extract, %	29.0 ± .84		29.3 ± .91		.7812
Protein, %	15.4 ± .22		15.3 ± .24		.8704

^aPredicted using equation developed by Hankins and Howe (1946).

TABLE 35. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ENERGY IN THE SOFT TISSUE OF THE CARCASS AND ENERGY DEPOSITED IN THE SOFT TISSUES DURING THE FEEDLOT PHASE, BY DIET

Trait	Diet				P
	Control		Fat		
	LS	Mean SE	LS	Mean SE	
Number of carcasses	25		22		
Energy from protein ^a , Mcal	205.6 ±	4.89	206.5 ±	5.29	.8997
Energy from fat ^b , Mcal	637.3 ±	21.66	652.6 ±	23.44	.6343
Total energy, Mcal	842.9 ±	22.04	859.1 ±	23.85	.1575
Total energy deposited, Mcal	534.0 ±	23.0	563.3 ±	24.8	.3925

^aCalculated using equation developed by Garrett (1958).

^bCalculated using equation developed by Blaxter and Rook (1953).

TABLE 36. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR AVERAGE DAILY GROSS ENERGY INTAKE, ESTIMATED AVERAGE DAILY ENERGY DEPOSITED IN SOFT TISSUES OF THE CARCASS AND EFFICIENCY OF GROSS ENERGY UTILIZATION, BY DIET

Trait	Diet				P
	Control		Fat		
	LS	Mean SE	LS	Mean SE	
Number of animals	25		22		
Average daily gross energy intake, Mcal	38.9 ± .73		40.8 ± .78		.0777
Average daily energy deposited, Mcal	4.4 ± .22		4.7 ± .25		.3602
Efficiency of gross energy utilization, %	11.2 ± .54		11.4 ± .57		.8013

Breed Type

Least squares means and standard errors for separable components of the carcass and chemical composition of the soft tissues of the carcass are presented in tables 37 and 38, respectively, by breed type.

Brahman-European crossbreds had about the same estimated percent of separable lean ($P > .8233$), fat ($P > .8668$) and bone ($P > .5134$) in the carcass as the European crossbred steers. Also, there was no difference ($P > .3188$) between steers of the two-breed types in the chemical composition of the soft tissues (fat and lean) of the carcass (table 38).

Least squares breed type means and standard errors for energy deposited in the soft tissue of the carcass and efficiency of gross energy utilization, respectively, are presented in tables 39 and 40. European crossbred and Brahman-European crossbred steers did not differ in estimated energy in the soft tissues of carcass, although the Brahman crossbreds tended ($P < .2046$) to have more energy in the form of fat. The total energy deposited in the soft tissues of the carcass during the feedlot phase was higher ($P < .0580$) for Brahman-European crossbreds (581.7 Mcal) than for European crossbred steers (515.6 Mcal)(table 39). The difference between the two breed types in total energy deposited in the carcass during the feedlot phase was due to the fact that the European crossbred steers slaughtered at the initiation of each feedlot period had a higher energy content of the soft tissues (331 Mcal) than did the Brahman-European crossbred steers (284 Mcal)(table A-2). Since they were slaughtered at the same endpoint of 1.0 cm outside fat, the

TABLE 37. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CARCASS COMPOSITION, BY BREED TYPE

Trait ^a	Breed				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Separable lean, %	55.9 ± .66		55.6 ± .71		.8233
Separable fat, %	29.4 ± .82		29.2 ± .88		.8668
Separable bone, %	15.7 ± .31		16.0 ± .34		.5134

^aPredicted using equation developed by Hankins and Howe (1946).

TABLE 38. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CHEMICAL COMPOSITION OF SOFT TISSUES OF THE CARCASS, BY BREED TYPE

Trait ^a	Breed				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Moisture, %	54.1 ± .66		55.1 ± .76		.3188
Ether extract, %	29.7 ± .82		28.7 ± .93		.4242
Protein, %	15.4 ± .22		15.4 ± .25		.9748

^aPredicted using equation developed by Hankins and Howe (1946).

TABLE 39. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED ENERGY IN THE SOFT TISSUES OF THE CARCASS AND ENERGY DEPOSITED IN THE SOFT TISSUES DURING THE FEEDLOT PHASE, BY BREED TYPE

Trait	Breed				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Energy from protein ^a , Mcal	208.9 ± 4.73		203.2 ± 5.4		.4400
Energy from fat ^b , Mcal	665.5 ± 20.99		624.3 ± 24.05		.2046
Total energy deposited, Mcal	581.7 ± 23.0		515.6 ± 24.8		.0580

^aCalculated using equation developed by Garrett (1958).

^bCalculated using equation developed by Blaxter and Rook (1953).

TABLE 40. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CARCASS COMPOSITION, BY BREED TYPE

Trait	Breed				P
	Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	
Number of animals	25		22		
Average daily gross energy intake, Mcal	40.1 ± .73		39.6 ± .78		.6843
Average daily energy deposited, Mcal	4.8 ± .23		4.3 ± .24		.1862
Efficiency of gross energy utilization, %	11.8 ± .54		10.8 ± .58		.2166

Brahman crossbreds would have deposited more total energy. Although the Brahman-European crossbred steers deposited more total energy during the feedlot phase (table 39), the average daily energy deposited in the soft tissues of the carcass (4.8 Mcal/day) was not different ($P > .1862$) from the average daily energy deposited in soft tissues of the European crossbred steers (4.3 Mcal/day)(table 40). Since average daily gross energy intake did not differ ($P > .6843$) between the two breed types (table 40), no difference ($P > .2166$) was found between them for efficiency of energy utilization.

Diet and Breed Type Interaction

The interaction of diet and breed type did not significantly affect the estimated physical composition (table 41) or estimated chemical composition of the fat and lean of the carcass (table 42). However, there was a tendency for the interaction of the two variables to affect percent separable lean ($P < .1091$) and percent separable fat ($P < .1715$). The Brahman-European crossbred steers fed the control diet tended to have a higher percentage of lean and lower percentage of fat than the same breed type steers fed the fat added diet. Opposite results were observed for the European crossbred steers fed the two diets. There was no diet by breed type interaction for estimated percent separable bone ($P > .8944$).

Least squares diet by breed type means and standard error are presented in tables 43 and 44, respectively, for total energy deposited in the soft tissues of the carcass during the feedlot phase and estimated energy efficiency, expressed as percent of gross energy consumed that was deposited in the soft tissues of the carcass. Diet

TABLE 41. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CARCASS COMPOSITION, BY DIET AND BREED TYPE

Breed Type Diet Trait ^a	Brahman-European crossbred				European crossbred				P
	Control		Fat		Control		Fat		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of carcasses	12		13		13		9		
Separable lean, %	56.9 ± .95		54.8 ± .91		55.1 ± .91		56.2 ± 1.10		.1091
Separable fat, %	28.3 ± 1.19		30.5 ± 1.13		29.8 ± 1.13		28.6 ± 1.36		.1715
Separable bone, %	15.8 ± .45		15.7 ± .43		16.0 ± .43		16.1 ± .52		.8944

^a Predicted using equation developed by Hankins and Howe (1946).

TABLE 42. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CHEMICAL COMPOSITION OF SOFT TISSUES OF THE CARCASS, BY DIET AND BREED TYPE

Breed Type Diet Trait ^a	Brahman-European crossbred				European crossbred				P
	Control		Fat		Control		Fat		
	LS	SE	LS	SE	LS	SE	LS	SE	
Number of carcasses	12		13		13		9		
Moisture, %	54.5 ±	.97	53.7 ±	.87	54.9 ±	.96	55.3 ±	1.17	.5211
Ether Extract, %	29.1 ±	1.20	30.3 ±	1.11	28.9 ±	1.19	28.4 ±	1.45	.1513
Protein, %	15.6 ±	.32	15.1 ±	.29	15.2 ±	.32	15.6 ±	.39	.4966

^aPredicted using equation developed by Hankins and Howe (1946).

by breed type interaction did not affect ($P > .8588$) the total estimated energy deposited in the carcass during the feedlot phase (table 43).

Diet by breed interaction tended ($P < .1055$) to affect average daily gross energy intake (table 44). Brahman-European crossbred steers fed the fat added diet tended to have a higher daily intake of gross energy (41.9 Mcal) than the Brahman-European crossbred steers fed the control diet (38.2 Mcal). No difference was found in daily gross energy intake between the European crossbred steers fed the fat added diet and those fed the control diet. Since average daily energy deposited in the carcass by steers by the two breed types within each season was proportional to daily energy intake, there was no diet by breed type interaction effect ($P > .9951$) on efficiency of energy utilization.

Feeding Period

Least squares feeding period means are shown in tables 45 and 46, respectively, for estimated physical and chemical compositions of the carcass. Steers fed during the cool period had a higher ($P < .0147$) percent lean in the soft tissues of the carcass and a corresponding lower ($P < .0396$) percent fat than those fed during the warm period. This difference, in percent of fat in the soft tissues of the carcass, between steers fed during the cool and warm periods was expected since feeding period affected outside fat ($P < .0243$)(table 24). There was no difference ($P > .8914$) in percent separable bone in the carcass of steers fed during the cool and warm periods. Feeding period did not affect ($P > .1789$) estimated chemical compositions of the soft tissues of the carcass (table 46).

TABLE 43. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED ENERGY IN SOFT TISSUES OF THE CARCASS AND ENERGY DEPOSITED IN SOFT TISSUES OF THE CARCASS DURING THE FEEDLOT PHASE, BY DIET AND BREED TYPE

Breed Type Diet Trait	Brahman-European crossbred				European crossbred				P
	Control		Fat		Control		Fat		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of carcasses	12		13		13		9		
Energy from protein ^a , Mcal	209.0 ± 6.96		208.8 ± 6.42		202.2 ± 6.86		204.2 ± 8.4		.8791
Energy from fat ^b , Mcal	640.6 ± 30.8		690.4 ± 28.46		634.0 ± 30.43		614.7 ± 37.26		.2861
Total energy deposited, Mcal	564.0 ± 33.34		599.3 ± 31.68		504 ± 31.68		527 ± 38.20		.8588

^aCalculated using equation developed by Garrett (1958).

^bCalculated using equation developed by Blaxter and Rook (1953).

TABLE 44. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR AVERAGE DAILY GROSS ENERGY INTAKES, ESTIMATED AVERAGE ENERGY DEPOSITED IN SOFT TISSUES OF THE CARCASS AND EFFICIENCY OF GROSS ENERGY UTILIZATION, BY DIET AND BREED TYPE

Breed Type Diet Trait	Brahman-European crossbred				European crossbred				P
	Control		Fat		Control		Fat		
	LS	SE	LS	SE	LS	SE	LS	SE	
Number of animals	12		13		13		9		
Average daily gross energy intake, Mcal	38.2 ± 1.05		41.9 ± 1.00		39.6 ± 1.00		39.7 ± 1.02		.1055
Average daily energy deposited, Mcal	4.5 ± .33		5.0 ± .31		4.3 ± .31		4.3 ± .38		.4906
Efficiency of gross energy utilization, %	11.7 ± .78		11.9 ± .74		10.7 ± .74		10.9 ± .89		.9951

TABLE 45. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED PHYSICAL COMPOSITION OF THE CARCASS, BY PERIOD

Trait ^a	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Separable lean, %	57.0 ± .66		54.8 ± .71		.0147
Separable fat, %	28.0 ± .82		30.6 ± .88		.0396
Separable bone, %	15.9 ± .31		15.8 ± .34		.8914

^aPredicted using equation developed by Hankins and Howe (1946).

TABLE 46. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CHEMICAL COMPOSITION OF SOFT TISSUES OF THE CARCASS, BY PERIOD

Trait ^a	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Moisture, %	55.3 ± .66		53.9 ± .75		.1789
Ether extract, %	28.4 ± .82		29.9 ± .93		.2632
Protein, %	15.5 ± .22		15.2 ± .25		.4612

^aPredicted using equation developed by Hankins and Howe (1946).

Least squares means for total energy deposition in the carcass and energy efficiency are presented in tables 47 and 48, respectively. Since outside fat and percent of separable fat in the carcass were higher for steers fed during the warm period than those fed during the cool period, estimated carcass energy from fat also was higher ($P < .0592$) for steers fed during the warm period. However, estimated total energy deposited in the soft tissues of the carcass during the feedlot period did not differ ($P > .7411$) by period. This result was to be expected, since steers fed during warm period had more total estimated energy in the soft tissues of the carcasses (359 Mcal) at the start of the feedlot period than did those fed during the cool period (258 Mcal)(table A-2).

Steers fed during the warm period had a higher average daily gain ($P < .0637$) and required fewer days on feed ($P < .0001$) to reach the slaughter point than those fed during the cool period. Thus, average daily energy deposited in the soft tissues of the carcass was higher ($P < .0002$) for steers fed during the warm period (5.2 Mcal/day) than for those fed during the cool period (3.9 Mcal/day)(table 48). Steers fed during the warm period had a heavier average initial weight than those fed during the cool period and also had a higher average daily gross energy intake. Efficiency of gross energy utilization was higher ($P < .0122$) for steers fed during the warm period (12.4%) than for those fed during the cool period (10.3%).

Diet and Feeding Period Interaction

Least squares diet by feeding period means and standard errors are presented in tables 49 and 50, respectively, for estimated physical and chemical carcass composition. The interaction of diet

TABLE 47. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED ENERGY IN SOFT TISSUES OF THE CARCASS AND ENERGY DEPOSITED IN THE SOFT TISSUES OF THE CARCASS DURING THE FEEDLOT PHASE, BY PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of carcasses	25		22		
Energy from protein ^a , Mcal	202.5 ± 4.77		209.6 ± 5.40		.3283
Energy from fat ^b , Mcal	613.9 ± 21.12		676.0 ± 23.93		.0592
Total energy deposited, Mcal	554.3 ± 23.0		543.0 ± 24.8		.7411

^aCalculated using equation developed by Garrett (1958).

^bCalculated using equation developed by Garrett (1953).

TABLE 48. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR AVERAGE DAILY GROSS ENERGY INTAKE, ESTIMATED AVERAGE ENERGY DEPOSITED IN SOFT TISSUES OF THE CARCASS AND EFFICIENCY OF GROSS ENERGY UTILIZATION, BY PERIOD

Trait	Period				P
	Cool		Warm		
	LS Mean	SE	LS Mean	SE	
Number of animals	25		22		
Average daily gross energy intake, Mcal	37.4 ± .73		42.3 ± .78		.0001
Average daily energy deposited, Mcal	3.9 ± .23		5.2 ± .24		.0002
Efficiency of gross energy utilization, %	10.3 ± .54		12.4 ± .57		.0122

TABLE 49. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED PHYSICAL COMPOSITION OF THE CARCASS, BY DIET AND PERIOD

Period Diet a Trait	Cool				Warm				P
	Control		Fat		Control		Fat		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of carcasses	14		11		11		11		
Separable lean, %	57.1 ± .88		56.9 ± .99		54.9 ± .99		54.1 ± 1.03		.7301
Separable fat, %	28.0 ± 1.09		28.1 ± 1.23		30.2 ± 1.23		31.0 ± 1.27		.7676
Separable bone, %	15.9 ± .41		15.9 ± .46		15.8 ± .47		15.8 ± .48		.9688

^aPredicted using equation developed by Hankins and Howe (1946).

TABLE 50. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CHEMICAL COMPOSITION OF SOFT TISSUES OF THE CARCASS, BY DIET AND PERIOD

Period Diet Trait ^a	Cool				Warm				P
	Control		Fat		Control		Fat		
	LS	SE	LS	SE	LS	SE	LS	SE	
Number of carcasses	14		11		11		11		
Moisture, %	55.5 ± .92		55.1 ± .95		53.9 ± 1.00		54.0 ± 1.12		.7948
Ether extract, %	28.1 ± 1.14		28.8 ± 1.19		29.9 ± 1.24		29.8 ± 1.39		.7296
Protein, %	15.5 ± .30		15.5 ± .32		15.3 ± .33		15.2 ± .37		.9855

^aPredicted using equation developed by Hankins and Howe (1946).

and feeding period did not affect ($P > .7361$) estimated percent of separable lean, fat or bone (table 49). Also, diet and feeding period interaction did not affect ($P > .7296$) any of the chemical components of the carcass.

There was no difference ($P > .4822$) in estimated energy from protein, fat or total energy in the carcass, or in total energy deposited in the soft tissues of the carcass due to an interaction of diet by period (table 51). Also, the interaction of diet by feeding period did not affect average daily gross energy intake ($P > .2860$), average daily gross energy deposited in the carcass ($P > .2995$), or efficiency of gross energy utilization ($P > .4934$)(table 52).

Period and Breed Type Interaction

Least squares feeding period and breed type means and standard errors are presented in table 53 for percent separable lean, fat and bone in the carcass and table 54 for carcass chemical composition. The feeding period by breed type interaction affected ($P > .0044$) percent of separable lean in the carcass. European crossbred steers fed during the cool period had a higher percent of separable lean than the Brahman-European crossbreds fed during the same period. However, the Brahman-European crossbreds fed during the warm period had a higher percent of separable lean in the carcass than did the European crossbred steers fed during the warm period. Since European crossbred steers fed during the cool period had a larger ribeye area and larger ribeye area per 100 kg hot carcass than did the Brahman-European crossbred steers fed during the cool period (table 31), the greater percent of separable lean in the carcass was to be expected. The two breed types reversed rankings in the two periods for percent of

TABLE 51. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED ENERGY IN SOFT TISSUES OF THE CARCASS AND TOTAL ENERGY DEPOSITED IN THE SOFT TISSUES OF CARCASS DURING THE FEEDLOT PHASE, BY DIET AND PERIOD

Period Diet Trait		Cool			Warm			P
		Control LS Mean	SE	Fat LS Mean	Control LS Mean	SE	Fat LS Mean	
Number of carcasses		14		11	11		11	
Energy from protein ^a , Mcal		200.2 ± 6.61		204.7 ± 6.86	210.9 ± 7.20		208.3 ± 8.05	.6221
Energy from fat ^b , Mcal		596.5 ± 29.31		631.3 ± 30.42	678.0 ± 31.90		673.9 ± 35.67	.5456
Total energy, Mcal		796.8 ± 29.82		836.0 ± 30.95	889.0 ± 32.46		882.2 ± 36.29	.4822
Total energy deposited, Mcal		537.9 ± 30.4		570.6 ± 34.48	530.1 ± 34.48		555.9 ± 35.69	.9198

^aCalculated using equation developed by Garrett (1958).

^bCalculated using equation developed by Blaxter and Rook (1953).

TABLE 52. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR AVERAGE GROSS ENERGY INTAKE, AVERAGE DAILY ENERGY DEPOSITED IN SOFT TISSUES OF CARCASS AND EFFICIENCY OF GROSS ENERGY UTILIZATION, BY DIET AND PERIOD

Period Diet Trait	Cool				Warm				P
	Control		Fat		Control		Fat		
	LS	SE	LS	SE	LS	SE	LS	SE	
Number of animals	14		11		11		11		
Average daily gross energy intake, Mcal	38.2 ± 1.06		41.9 ± 1.00		39.6 ± 1.00		39.7 ± 1.21		.2860
Average daily energy deposited, Mcal/day	3.9 ± .30		3.8 ± .34		4.9 ± .34		5.5 ± .35		.2995
Efficiency of gross energy utilization, %	10.5 ± .71		10.1 ± .80		12.0 ± .80		12.7 ± .83		.4934

TABLE 53. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED PHYSICAL COMPOSITION OF THE CARCASS, BY PERIOD AND BREED TYPE

Period Breed type Trait ^a	Cool			Warm			P
	Brahman-European crossbred		European crossbred	Brahman-European crossbred		European crossbred	
	LS	Mean	SE	LS	Mean	SE	
Number of carcasses	13			12		10	
Separable lean, %	56.6 ± .91		58.3 ± .96	56.1 ± .96		52.9 ± 1.06	.0044
Separable fat, %	29.0 ± 1.31		27.1 ± 1.19	29.9 ± 1.19		31.3 ± 1.31	.1803
Separable bone, %	16.2 ± .43		15.6 ± .45	15.2 ± .45		16.5 ± .50	.0504

^a Predicted using equation developed by Hankins and Howe (1946).

TABLE 54. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED CHEMICAL COMPOSITION OF SOFT TISSUES OF THE CARCASS, BY PERIOD AND BREED TYPE

Period Breed type Trait ^a	Cool				Warm				P
	Brahman-European crossbred		European crossbred		Brahman-European crossbred		European crossbred		
	LS Mean	SE	LS Mean	SE	LS Mean	SE	LS Mean	SE	
Number of carcasses	13		12		12		10		
Moisture, %	54.2 ± .92		56.3 ± .95		54.0 ± .94		53.9 ± 1.17		.2849
Ether extract, %	29.6 ± 1.14		27.3 ± 1.19		29.7 ± 1.17		30.0 ± 1.45		.2865
Protein, %	15.5 ± .30		15.5 ± .32		15.2 ± .31		15.3 ± .39		.8854

^a Predicted using equation developed by Hankins and Howe (1946).

separable bone (table 53). The interaction of feeding period by breed type did not affect ($P>.2849$) percent moisture, ether extract, or protein in the soft tissues of the carcass (table 54).

Least squares feeding period and breed type means and standard errors for energy in the carcass and total energy deposited in the soft tissues of the carcass during the feedlot phase are presented in table 55, and for daily gross energy intake and energy deposited and efficiency of energy utilization in table 56. The feeding period by breed type interaction did not affect estimated total energy content of the carcass ($P>.7480$) or total energy deposited in the soft tissue of the carcass ($P>.3798$). Also, the interaction of feeding period by breed type did not affect average daily gross energy intake ($P>.9657$), average daily energy deposited in the soft tissues of the carcass ($P>.5529$) or efficiency of gross energy utilization ($P>.3935$)(table 56).

TABLE 55. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR ESTIMATED ENERGY DEPOSITED IN SOFT TISSUES OF THE CARCASS AND TOTAL ENERGY DEPOSITED IN THE SOFT TISSUES OF CARCASS DURING THE FEEDLOT PHASE, BY PERIOD AND BREED TYPE

Period Breed type Trait	Cool			Warm			P
	Brahman-European crossbred	European crossbred		Brahman-European crossbred	European crossbred		
	LS Mean	SE		LS Mean	SE		
Number of carcasses	13		12	12		10	
Energy from protein ^a , Mcal	200.5 ± 6.62		204.4 ± 6.87	217.2 ± 6.78		202.1 ± 8.40	.1956
Energy from fat ^b , Mcal	634.0 ± 29.3		593.8 ± 30.42	697.1 ± 30.04		654.9 ± 37.26	.9747
Total energy, Mcal	834.6 ± 29.82		798.3 ± 30.95	914.2 ± 30.56		856.9 ± 37.91	.7480
Total energy deposited, Mcal	602.3 ± 31.68		506.2 ± 33.35	561.0 ± 33.35		525.0 ± 36.76	.3798

^aCalculated using equation developed by Garrett (1958).

^bCalculated using equation developed by Blaxter and Rook (1953).

TABLE 56. LEAST SQUARES MEANS, STANDARD ERRORS AND PROBABILITIES FOR AVERAGE GROSS ENERGY INTAKE, ESTIMATED AVERAGE ENERGY DEPOSITED IN SOFT TISSUES OF THE CARCASS AND EFFICIENCY OF GROSS ENERGY UTILIZATION, BY PERIOD AND BREED TYPE

Period Breed type Trait	Cool				Warm				P
	Brahman-European crossbred		European crossbred		Brahman-European crossbred		European crossbred		
	LS	Mean	SE		LS	Mean	SE		
Number of animals	13			12	12			10	
Average daily gross energy intake, Mcal	37.6 ± 1.00			37.2 ± 1.05	42.6 ± 1.05			42.11 ± 1.16	.9657
Average daily energy deposited, Mcal	4.2 ± .31			3.5 ± .33	5.3 ± .33			5.1 ± .36	.5529
Efficiency of gross energy utilization, %	11.1 ± .74			9.5 ± .78	12.5 ± .78			12.2 ± .86	.3935

GENERAL DISCUSSION AND CONCLUSIONS

The feedlot performance of the two breed types of steers was excellent during both the cool and warm feeding periods. The overall average daily gain of 1.59 kg was equal to feedlot performance reported in the major cattle feeding areas of the United States and the efficiency of feed utilization for gain (5.18 kg of dry matter per kilogram liveweight gain), likewise compared well. The average USDA quality grade of Good and yield grade of 2.8 were very acceptable, considering the quality of the cattle used in this study. Seventy percent of the carcasses met the "Tender Trim" requirements. Fewer of the Brahman-European crossbred steer carcasses (15 of 25 or 60%) met the "Tender Trim" requirements than of the carcasses of the European crossbreds (18 of 22 or 82%). Of the carcasses not meeting "Tender Trim" specifications, 10 of the 14 did not have the required minimum marbling score of Slight⁰. Twenty-eight percent of the carcasses of the Brahman-European crossbred steers did not meet the minimum marbling requirements for "Tender Trim", whereas only 14% of the European crossbreds did not meet this requirement.

Previous research has shown a decreased feedlot performance for steers fed during the hot period of the year in warm climate regions. In this study, steers fed in the summer gained more rapidly (1.69 kg/d) than those fed in the cool period (1.51 kg/d). Steers of both breed types were purchased from south-central Florida ranches and probably were relatively well adapted to the climatic conditions of Florida.

This adaptation, plus the fact that steers fed in the warm period were long yearlings, probably accounted for the excellent feedlot performance of the steers fed during the warm season. Satisfactory feedlot facilities with adequate shade probably contributed to the excellent feedlot performance during the warm season.

The lack of a breed type by period interaction effect on feedlot performance may have been due to the lack of a clear-cut separation of the two breed types. Many of the steers classified as European crossbreds had some, but it was estimated that they had less than one-fourth, Brahman breeding. Exact breed composition was unknown, and it was likely that many of the steers could be traced back to "Florida Native" breeding. Thus, both breed types probably were adapted to warm climate conditions.

Appetite was not reduced during the warm season and the addition of fat to the diet did not improve feedlot performance during the warm period.

The addition of an unprotected fat to the diet did result in a decrease in USDA quality grade. Steers fed the fat added diet had an average quality grade of Low Good (marbling score of Slight²⁰) versus a quality grade of High Good (marbling score of Slight⁸⁶) for steers consuming a control diet. This negative response to the feeding of fat is of economic importance in Florida where lack of gradeability is one of the problems encountered by feedlot operators and by packers.

Based on the results of this study, it is possible to conclude that:

- Satisfactory feedlot performance can be obtained in both the cool and warm periods of the year in Florida.
- The addition of 4% of unprotected fat to the diet did not improve rate or efficiency of gain in either the warm or cool periods of the year.
- The addition of 4% of unprotected fat to the diet did decrease quality grade by about 2/3 of a grade.
- The feeding of fat was not economical. It did not improve feedlot performance, costs about three times as much per kg as corn, and decreased the value of the carcass.

SUMMARY

Forty-seven crossbred steers, approximately 10 to 11 months of age, were used to study the effects of added fat in the diet (control versus fat added), breed type (Brahman-European crossbreds versus European crossbred steers) and feeding period (cool versus warm) on feedlot performance and carcass characteristics. One-half of the steers of each breed type in each period was fed a control diet and the other one-half received a fat added diet, in which fat comprised 4% of the diet. Steers fed during the cool period were implanted with Zeranol at the beginning of the experiment and implanted with Synovex-S 75 days later. Steers fed in the warm period were implanted three times with Zeranol during the backgrounding phase and implanted with Synovex-S at the beginning of the feedlot phase and again 75 days later. Eight steers, four European and four Brahman-European crossbred, were used in two digestion trials and an equal number of each breed type was used for comparative slaughter.

The overall means for initial and final weights, days on feed, average daily gain and feed efficiency were 269 kg, 467 kg, 126 d, 1.59 kg and 5.18 kg DM/kg gain. The substitution of fat for high moisture corn did not improve ($P > .60$) the feedlot performance. Steers fed the fat added diet had a higher ($P < .0777$) average daily gross energy intake (40.84 Mcal) than those fed the control diet (39.80 Mcal). Addition of fat to the diet increased ($P < .0001$) digestible ether extract of the diet from 3.25% for the control to 6.59% for the

fat added diet. Digestible energy was higher ($P < .0347$) for the fat added diet (3.46 Mcal/kg dry matter) than for the control diet (3.24 Mcal/kg dry matter). There was no difference ($P > .7945$) in digestible energy intake between steers fed the two diets.

Breed type did not affect ($P > .4430$) any of the feedlot traits studied. The diet by breed type interaction affected ($P < .0599$) average daily gain. Brahman-European crossbred steers fed the fat added diet gained more rapidly (1.66 kg/day) than those fed the control diet (1.53 kg/day). However, European crossbreds fed the control diet had a higher average daily gain (1.64 kg) than those fed the fat added diet (1.51 kg).

Feeding period affected feedlot gain ($P < .0637$). Steers fed during the warm period gained faster (1.65 kg/day) than those fed during the cool period (1.52 kg/day). The average daily dry matter intake and average daily gross energy intake were higher ($P < .0001$) for steers fed during the warm period. The interaction of diet and feeding period affected ($P < .0748$) days on feed to reach 1.0 cm outside fat. Steers fed the fat added diet during the cool period required more days on feed than did those fed the control diet (151 versus 139 d). This difference in number of days on feed between steers fed the two diets decreased during the cool period (109 versus 102 d) for steers fed the control and the fat added diets, respectively. Feeding period by breed type interaction did not affect ($P > .1750$) any of feedlot traits.

Diet affected ($P < .0945$) USDA yield grade. Steers fed the control diet had a better yield grade (2.7) than those fed the fat added diet (2.9). Fat added to the diet negatively affected marbling score

($P < .0011$). The average marbling score for the carcasses of steers fed the control diet was Slight⁸⁶ versus Slight²⁰ for those fed the fat added diet. Loin steaks from steers fed the fat added diet were more juicy ($P < .0290$) than those from steers fed the control diet. There was no difference ($P > .6733$) in the Warner-Bratzler shear force values for steaks from steers fed the two diets. Diet did not affect ($P > .5480$) flavor.

Brahman-European crossbred steers had a heavier ($P < .0008$) hide weight (40.3 kg) than European crossbreds (35.1 kg). Slaughter weight was similar ($P > .4195$) for steers of both breed types. Both breed types had an average USDA yield grade of 2.8. European crossbred steers, however, had a higher ($P < .0974$) percent kidney, pelvic and heart fat than the Brahman-European crossbred steers. No differences ($P > .40$) were found between steers of the two breed types for USDA quality grade or carcass maturity. Loin steaks from European crossbred steers were more juicy ($P < .0916$) and tender ($P < .0856$), as measured by sensory panel, and had a lower ($P < .0092$) shear force value than loin steaks from Brahman-European crossbreds. European crossbreds had a lower ($P < .0757$) connective tissue score (5.1) than Brahman-European crossbreds (5.6).

The interaction of diet and breed type did not affect ($P > .12$) any of the carcass characteristics of palatability attributes evaluated in this study.

Steers fed during the warm period had a greater ($P < .0023$) slaughter weight (466 kg) than those fed during the cool period (434 kg). Steers fed during the cool period had a better ($P < .0514$) yield grade (2.7) than those fed during the warm period (3.0). Ribeye area

per 100 kg hot carcass was higher ($P < .0260$) for steers fed during the cool period (26.17 cm^2) than for steers fed during the warm period (24.38 cm^2). Feeding period affected ($P < .0994$) hot carcass weight, 270 kg for steers fed during the cool period versus 283 kg for steers fed during the warm period.

There was no difference ($P > .50$) in sensory panel scores for juiciness, tenderness or connective tissue of steaks from steers fed during the two periods of the year. Steaks from steers fed during the warm period had a lower ($P < .0365$) Warner-Bratzler shear force value.

Diet by feeding period interaction did not affect ($P > .16$) any of the carcass characteristics, except for empty body weight ($P < .0865$), or palatability attributes evaluated in this study.

The interaction of feeding period and breed type affected ($P < .015$) ribeye area, ribeye area per 100 kg hot carcass and USDA yield grade. European crossbred steers fed during the cool period had a better yield grade (2.5) than Brahman-European crossbred steers fed during the same period (2.9). However, during the warm period, average yield grade was better for the Brahman-European crossbreds (2.8) than for the European crossbred steers (3.1). The interaction of breed type and period did not affect ($P > .3691$) carcass quality grade, any of the sensory characteristics or Warner-Bratzler shear force value for loin steaks.

Addition of fat to the diet did not affect ($P > .1575$) total energy in the soft tissues of the carcass, estimated total energy deposited in the soft tissues of the carcass during the feedlot phase, or efficiency of gross energy utilization.

Brahman-European crossbred steers had a higher ($P < .0580$) amount of estimated total energy deposited in the fat and lean of the carcass (581.7 Mcal) than the European crossbred steers (515.6 Mcal). However, breed type did not affect ($P > .2166$) efficiency of gross energy utilization. Diet by breed interaction did not affect ($P > .8588$) estimated total energy deposited in the soft tissues of the carcass during the feedlot phase or efficiency of gross energy utilization.

Steers fed during the cool period did not differ ($P > .7411$) from those fed during the warm period in estimated total energy deposited in the soft tissues of the carcass during the feedlot phase. However, average daily energy deposited in the soft tissues of the carcass and the efficiency of gross energy utilization were higher ($P < .012$) for steers fed during the warm period than for those fed during the cool period. Period by diet and period by breed interactions did not significantly affect estimated daily or total energy deposited in the soft tissues of the carcass or efficiency of gross energy utilization.

APPENDIX

TABLE A-1. APPARENT DIGESTIBILITY COEFFICIENTS OF NUTRIENTS AND THE DIGESTIBLE ENERGY CONTENT OF THE EXPERIMENTAL DIETS

Trait	Diet				P
	Control		Fat		
	Mean	SE	Mean	SE	
Number of steers	8		8		
Dry matter, %	71.17 ± .88		70.72 ± .85		.6361
Crude protein, %	64.30 ± 1.37		63.94 ± 1.57		.6415
Crude fiber, %	42.66 ± 1.97		41.78 ± 3.67		.7955
Ether extract, %	76.58 ± 2.81		84.85 ± 1.14		.0284
Nitrogen free extract, %	77.56 ± 1.00		78.63 ± 1.10		.1742
Digestible energy, %	67.69 ± 2.08		69.43 ± 1.19		.3190

TABLE A-2. MEANS AND STANDARD ERRORS FOR ESTIMATED ENERGY IN THE SOFT TISSUE (FAT AND MUSCLE) OF COMPARATIVE SLAUGHTER STEERS

Variable	n	Energy from protein ^a Mean SE	Energy from fat ^b (Mcal) Mean SE	Energy from fat ^b (Mcal) Mean SE	Total ^c energy (Mcal) Mean SE
Period					
Cool	4	111 ± 7.05		147 ± 18.19	258 ± 20.19
Warm	4	146 ± 5.45		213 ± 2.00	359 ± 19.90
Breed Type					
Brahman-European crossbred	4	125 ± 6.80		159 ± 9.00	284 ± 14.00
European crossbred	4	131 ± 6.50		200 ± 20.50	331 ± 24.60

^aCalculated using equation developed by Garrett (1958), 1 kg of protein = 5.686 Mcal.

^bCalculated using equation developed by Blaxter and Rook (1953), 1 kg of fat = 9.367 Mcal.

^cCalculated using equation, Total energy = Energy from protein + Energy from fat.

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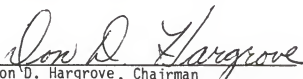
BIOGRAPHICAL SKETCH

Sergio Marcondes Cesar was born March 26, 1947, in Sao Carlos, Sao Paulo, Brazil. He attended public school in Ibitinga. In 1973, he received the degree Engenheiro Agronomo from the Escola Superior de Agricultura "Luiz de Queiroz" of the University of Sao Paulo. In 1974, he accepted a position on the staff of the Instituto de Zootecnia of the Secretaria da Agricultura do Estado de Sao Paulo in the area of beef cattle management research. Nine scientific publications resulted from research in this position.

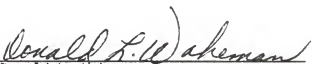
He was accepted in 1979 into the Graduate School at the University of Florida. In May, 1982, Sergio received the Master of Science degree in animal science from the University of Florida. He continued his graduate studies toward the Ph.D. degree in animal science at the University of Florida. Sergio is a member of the Sociedade Brasileira de Zootecnia, the Conselho Regional de Agricultura e Engenharia de Sao Paulo, and the American Society of Animal Science.

He was married on August 2, 1975, to Regina Celia Rasteiro, and they have one son, Sergio Marcondes Cesar Filho, born on May 18, 1976.

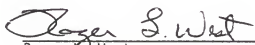
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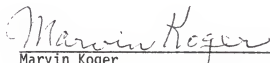
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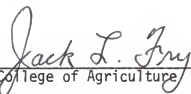
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John Holt
Professor of Food and Resource
Economics

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate School, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

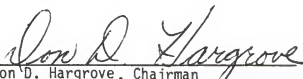
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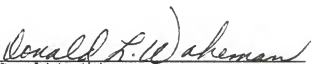
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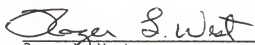
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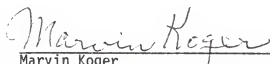
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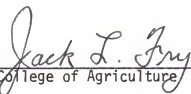
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August, 1984



Dean, College of Agriculture

Dean for Graduate Studies and Research